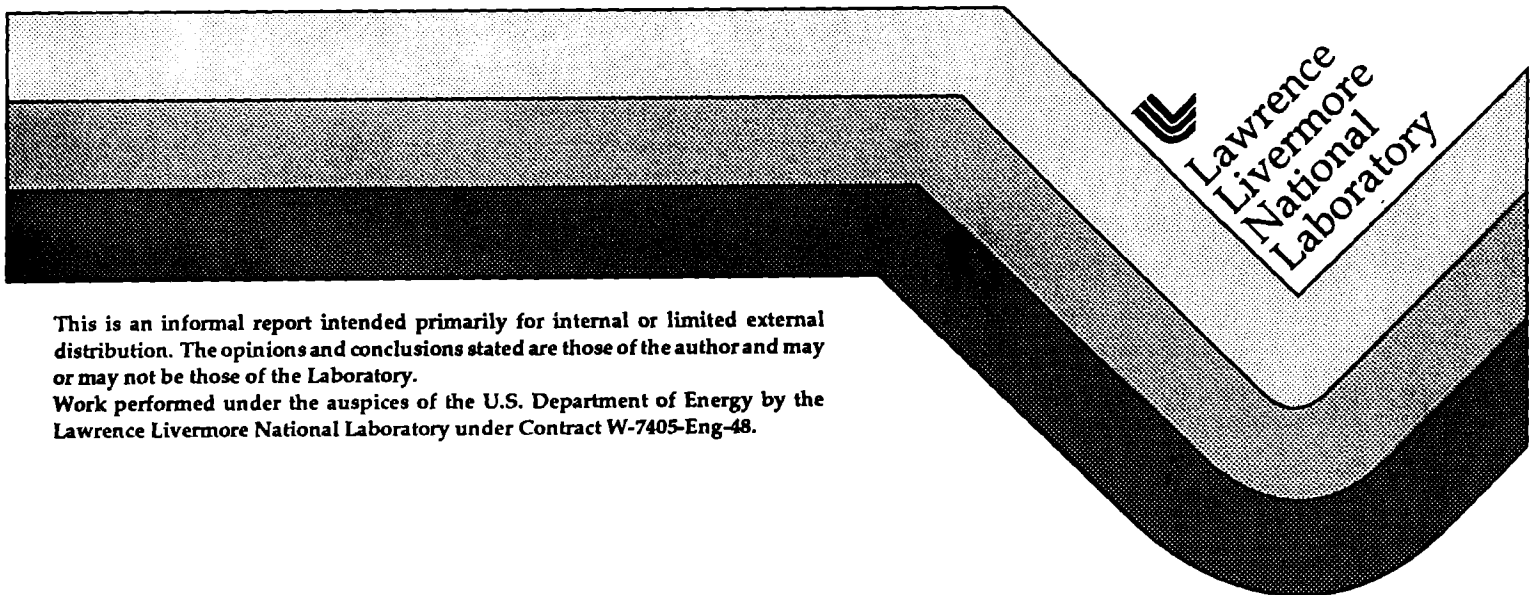


# **Radon Data Acquisition: An Automated System for Radon Analysis of Both Ground Air and Tower Air and for the Simultaneous Logging of Meteorological Data**

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October 1990



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## Table of Contents

Abstract.....	v
<b>1.0 Introduction.....</b>	<b>1-1</b>
Reference.....	1-1
<b>2.0 Radon-Monitor Controller.....</b>	<b>2-1</b>
2.1 RMC Actuator Unit.....	2-1
2.1.1 Scanivalves.....	2-3
2.1.2 Passive Syringe.....	2-3
2.2 Tower-Air Sampling.....	2-4
2.3 Manual Operation.....	2-5
2.3.1 Scanivalve.....	2-5
2.3.2 The AIR Switch.....	2-5
2.3.3 The DRAW Switch.....	2-7
2.3.4 The DELIVER Switch.....	2-7
2.3.5 The PURGE-1 Switch.....	2-7
2.3.6 The PURGE-2 Switch.....	2-7
2.4 RMC Control Unit.....	2-8
2.4.1 RMC Microprocessor.....	2-8
2.4.2 RMC Support Card.....	2-8
2.4.3 RMC External Switches and Connections.....	2-11
2.4.4 External Wiring Interface.....	2-11
2.5 Firmware Description, Version V.8.....	2-15
2.5.1 MENU Mode.....	2-15
2.5.2 RUN Mode.....	2-19
2.6 RUN Mode Events.....	2-19
2.6.1 Common Events.....	2-20
2.6.2 Ground-Air Sampling Events.....	2-21
2.6.3 Tower-Air Sampling Events.....	2-21
References.....	2-21
<b>3.0 Communication-Software Description.....</b>	<b>3-1</b>
3.1 RADCON.EXE.....	3-1
3.1.1 Function Keys.....	3-2

3.1.2	Program Features.....	3-3
3.1.3	WLM30 Mode.....	3-4
3.1.4	RMC Mode.....	3-4
3.2	MEX.COM.....	3-5
3.2.1	Running the Program.....	3-5
3.2.2	MEX Commands.....	3-5
3.3	WLM30.EXE.....	3-6
3.3.1	WLM-30 Setup.....	3-6
3.3.2	Data Retrieval.....	3-7
	References.....	3-7
<b>4.0</b>	<b>Radon Detectors.....</b>	<b>4-1</b>
4.1	WLM-30 Detector and Multi-Channel Analyzer.....	4-1
4.1.1	WLM-30 Operations.....	4-2
4.1.2	WLM-30 Maintenance.....	4-2
4.1.3	WLM-30 Calibration.....	4-2
4.2	RD-200 Detector.....	4-3
4.2.1	RD-200 Operations.....	4-3
4.2.2	RD-200 Maintenance.....	4-4
4.2.3	Calibration.....	4-4
4.3	TN-RG-20 Radon Detector.....	4-4
4.3.1	TN-RG-20 Operations.....	4-5
4.3.2	TN-RG-20 Maintenance.....	4-5
4.3.3	TN-RG-20 Calibration.....	4-5
4.3.4	TN-RG-20 Data Acquisition.....	4-5
	References.....	4-6
<b>5.0</b>	<b>AIR-DB Software and Hardware Description.....</b>	<b>5-1</b>
5.1	Software Initialization.....	5-1
5.2	Running the Program.....	5-2
5.3	AIR-DB Command Set.....	5-2
5.4	Data Logging.....	5-2
<b>6.0</b>	<b>HANDLAP Software Description.....</b>	<b>6-1</b>
6.1	Software Initialization.....	6-1
6.2	Running the Program.....	6-2



6.2.1 Method 1: Automatic Mode .....	6-2
6.2.2 Method 2: Interactive Mode .....	6-2
6.2.3 Method 3: Menu Mode .....	6-2
6.2.4 Changing the Data-Logging Disk Drive .....	6-4
6.3 Interactive Mode Commands .....	6-4
6.4 Data Files .....	6-4
6.5 HANDAR 540A Configuration .....	6-5
6.6 HANDAR Commands .....	6-14
6.6.1 HANDAR Time .....	6-14
6.6.2 PROGRAM/RUN Mode .....	6-14
Reference .....	6-15
<b>7.0 Radon Data-Acquisition Procedures .....</b>	<b>7-1</b>
7.1 Setting Up the Experiment .....	7-1
7.1.1 System Power .....	7-1
7.1.2 Turn the System On .....	7-2
7.1.3 Check System Interconnections .....	7-3
7.1.4 Equipment Initialization — Cold Start .....	7-5
7.2 Monitoring the Experiment .....	7-6
7.2.1 Software/Firmware Checks .....	7-6
7.2.2 Hardware Checks .....	7-7
7.3 Near Real-Time Data Logging .....	7-7
7.3.1 WLM-30 Near Real-Time Data Logging .....	7-7
7.3.2 RMC Near Real-Time Data Logging .....	7-7
7.4 Mid-Experiment Data Logging .....	7-8
7.4.1 Handar Data Logging .....	7-8
7.4.2 AIR-DB Data Logging .....	7-8
7.4.3 WLM-30 and RMC Data Logging .....	7-8
7.5 Terminating the Experiment .....	7-10
Appendix 7-A. Check Lists and Log Sheets .....	7-11

## List of Figures

2-1. Ground-air sampling system .....	2-2
2-2. Tower-air sampling system.....	2-3
2-3. RMC front panel.....	2-4
2-4. RMC manual switch circuit .....	2-6
2-5. RMC support card circuits .....	2-9
2-6. RMC DIP switch settings.....	2-9
2-7. RMC support card layout.....	2-9
2-8. RMC power and relay cables .....	2-12
2-9. RMC RS-232 cable wiring.....	2-12
2-10. RMC analog and digital connectors.....	2-13
2-11. Cable to T&N Radon detector.....	2-14
2-12. RMC actuator unit relay block.....	2-14
2-13. Firmware main menu.....	2-16
2-14. RMC system defaults and down-load format.....	2-18
2-15. Scanivalve position in A/D units .....	2-20
3-1. Main menu screen of RADCON.....	3-2
3-2. RADCON help menu for WLM-30 operations .....	3-3
4-1. Window settings for WLM-30 multi-channel analyzer .....	4-1
5-1. Sample AIR-DB.CFG file.....	5-1
6-1. Sample HANDCOM.CFG file.....	6-1
6-2. Example of HANDLAP main menu.....	6-3
6-3. Example of HANDLAP auxiliary menu.....	6-3
7-1. The radon-system-equipment interconnections.....	7-4

## Abstract

A system to acquire radon data was developed at Lawrence Livermore National Laboratory (LLNL) to provide information about the effect of weather conditions on the release of radon gas from soils into air. One of the system criteria that drove other design considerations was the need for operation at remote sites where the availability of 120-volt AC power was problematic. As a consequence, all components were selected or designed to run on +12 and/or -12 volts DC. PC-based laptop computers were used for all data acquisition because of their availability, their low power consumption, and the abundance of software written for this platform. The system is comprised of four major sub-systems that are linked by laptop computers: radon-monitor controller, HANDAR 540 data-capture platform, radon-detection units, and barometric pressure unit.

Using this system, we successfully collected data at an LLNL field site during 1990. Data from meteorological sensors and radon-concentration profiles from both air and soil were acquired simultaneously and logged on MS-DOS computers for data reduction at a future time. This document describes the functions, hardware, firmware, and software of this system.



## 1.0 Introduction

This radon data-acquisition system was developed in 1989 to be used in experiments designed to correlate changes in weather conditions to changes in radon ( $^{222}\text{Rn}$  and  $^{220}\text{Rn}$ ) flux from soil to air. This work was performed under the leadership of Dr. Joseph Shinn of Lawrence Livermore National Laboratory (LLNL).

Radon sampling procedures described by Rose et al.<sup>(1-1)</sup> were automated to allow round-the-clock ground-air monitoring from several different test holes made in previously undisturbed soil at LLNL. Holes were prepared with a single port in each one, as described by Rose et al.<sup>(1-1)</sup> Concrete was used as grout over the sand-filled sampling chamber. Air was sampled from several levels of a 2-meter tower while the ground air was being sampled.

One of the system criteria that drove other design considerations was the need for operation at remote sites where the availability of 120-volt AC power was problematic. To this end, all components were selected or designed to run on +12 and/or -12 volts DC. Solar panels were purchased to allow the 12-volt batteries to be charged when weather permitted.

PC-based laptop computers were used for all data acquisition because of their availability, their low power consumption, and the abundance of software written for this platform.

This system is comprised of four major sub-systems that are linked by the laptop computers:

- Radon-monitor controller.
- HANDAR 540 data-capture platform.
- Radon-detection units.
- Barometric pressure unit.

This document is a description of the functions, hardware, firmware, and software of this system.

## References

- 1-1. Rose, Arthur W., John W. Washington, and Daniel J. Greeman (1988), "Variability of Radon with Depth and Season in a Central Pennsylvania Soil Developed on Limestone," *Northeastern Environmental Science* 7(1), 35-39.



## 2.0 Radon-Monitor Controller

The radon monitor controller (RMC) unit was designed to automate gas sampling from ground air and from tower air based on the method described by Rose et al.<sup>(2-1)</sup> It is comprised of two discrete modules, the RMC control unit and the RMC actuator unit. The control unit is microprocessor based and is used to sequence the actuator unit. (The actuator unit may also be used in manual mode.) The RMC control unit can log up to 24 hours of analog data to its volatile memory from one 0- to 5-volt source and can provide regulated +5- and +12-volt power to other units.

The system has two primary functions. First, it multiplexes sample lines of tower air and of ground air from various locations to their respective radon detectors at pre-programmed times. Second, it provides a means whereby an exact volume of ground air may be taken just prior to its injection into a radon detector. Timing here is critical due to the short half-life of radon and its daughters. Ground-air sampling is accomplished by the use of a passive syringe. Figures 2-1 and 2-2 provide schematic diagrams of the sampling systems.

The RMC controls two Scanivalves (multiplexing valves, which are described in Section 2.1.1), three air pumps, and two 2-way valves. Through a combination of two of the pumps and the two 2-way valves, the passive syringe may be filled and emptied either manually or via the on-board microprocessor. Two micro switches are used to determine the position of the syringe plunger. By relocating the position of these switches, the volume of gas sampled by the syringe may be adjusted.

There are two ways to communicate with the RMC. The first is through a bank of pre-programmed switches. This allows the user to manually change Scanivalve position, to sample ground and tower air, and to purge the ground-air detector after counting has been completed.

The second way to communicate with the RMC is by use of a laptop computer connected by RS-232 serial line to the RMS's front panel (Figure 2-3). The computer may be programmed with any terminal-emulation program or with the software program, RADCON. These procedures are presented in Chapter 3.

### 2.1 RMC Actuator Unit

The RMC actuator unit measures approximately 18 inches by 24 inches by 5 inches. It contains a 1400-cc syringe with micro switches, two Scanivalves, four air

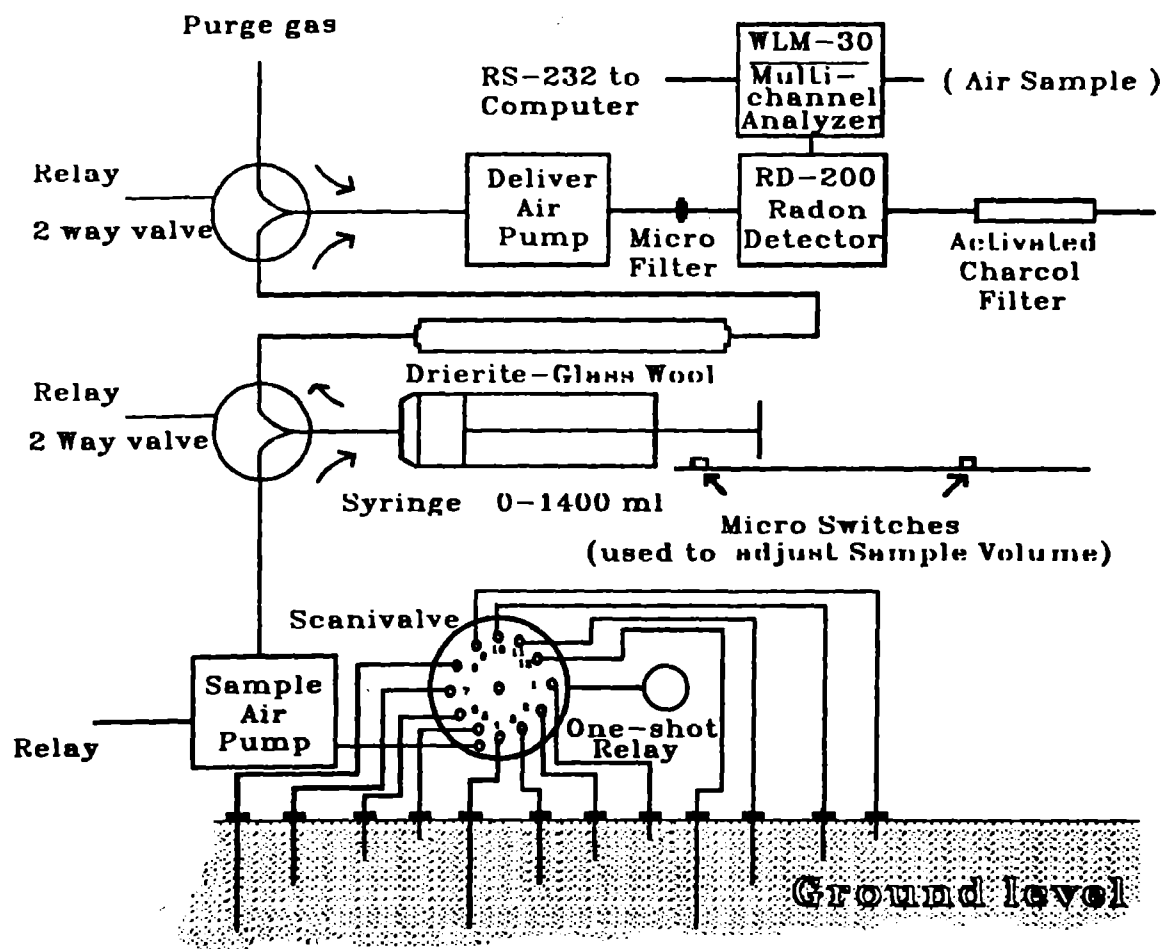


Figure 2-1. Ground-air sampling system.

pumps, two 2-way solenoid valves, and a solid-state relay (SSR) board. It is controlled by either the RMC control unit, which is described in section 2.4 of this chapter, or by the manual switch bank described in section 2.3.



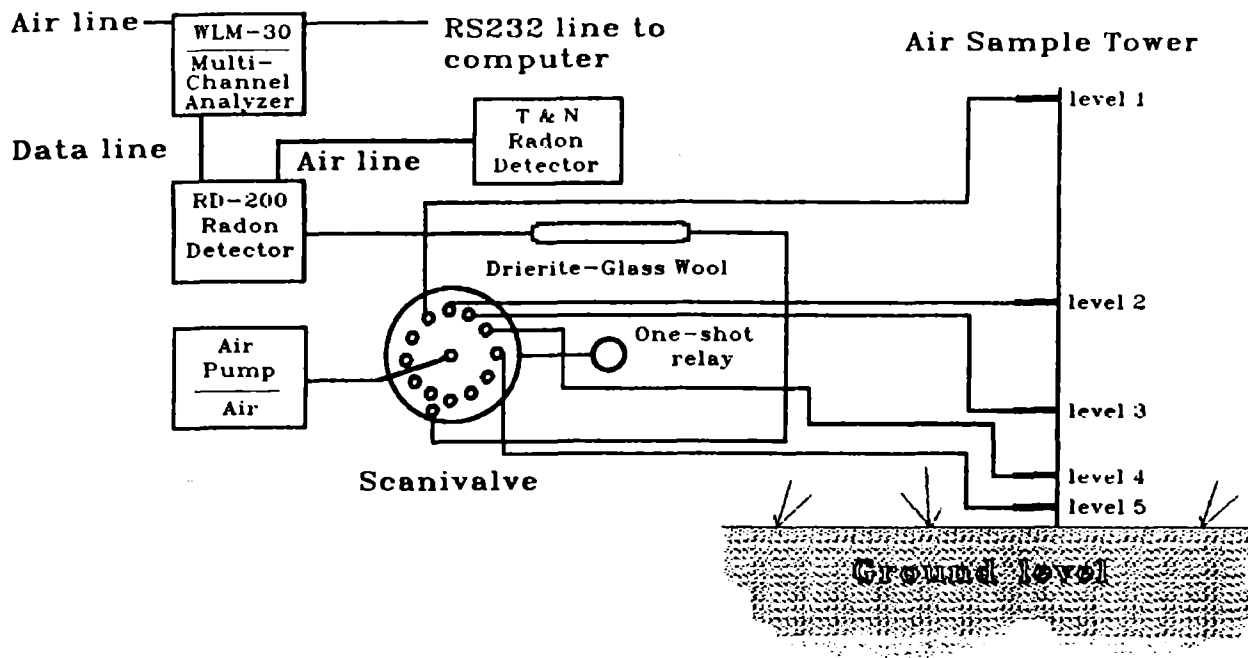


Figure 2-2. Tower-air sampling system.

### 2.1.1 Scanivalves

Scanivalves are produced by the Scanivalve Corporation of San Diego, California. Each has 12 sample-in ports, one sample-out port and one common-out port. The common-out port is a manifold that is connected to 11 of the in ports. The 12th sample-in port is connected to the sample-out port. The position of the latter may be changed by energizing an internal 24-volt DC solenoid. The position of the Scanivalve may be monitored by reading an analog voltage that varies with the position of the valve. By moving the Scanivalve from one position to another, the user may take gas samples from different areas.

A one-shot timed relay is used to ensure that the Scanivalve solenoid remains energized long enough to change position but not so long as to waste power.

### 2.1.2 Passive Syringe

The passive syringe sub-system is illustrated in Figure 2-1. It is comprised of two 24-volt DC air pumps, two micro switches, and two 2-way solenoid valves.

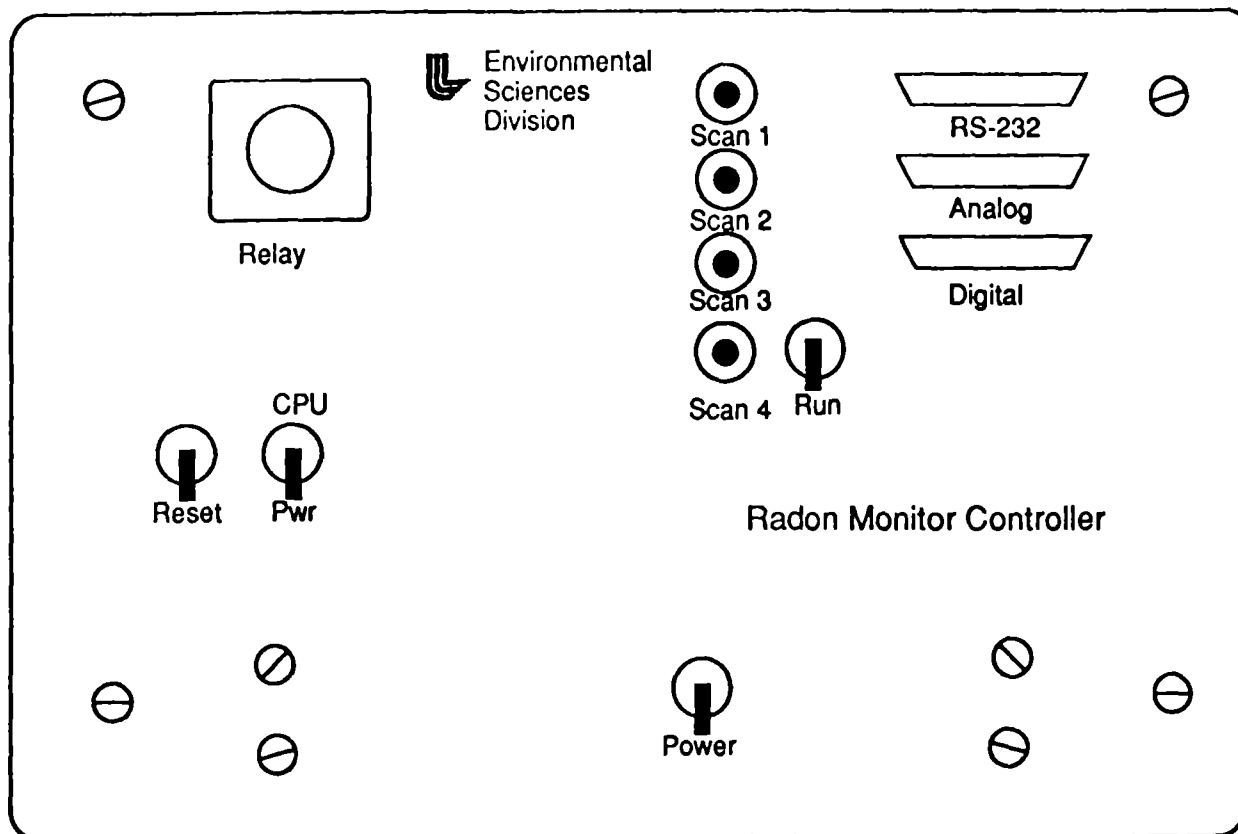


Figure 2-3. RMC front panel.

When a sample is taken, the first valve, called the SAMPLE valve, is positioned so that a path exists between the sample point and the syringe. The air pump, which is located between the sample point and the SAMPLE valve, is activated. Pumping continues until the outboard micro switch on the syringe is tripped. At this time, the SAMPLE valve is reversed, and the second valve, called the DELIVER valve, is turned toward the second pump, which is called the DELIVER pump. When the DELIVER pump is turned on, air is evacuated from the syringe until the inboard micro switch on the syringe is contacted. At this point, a sample of ground air has been delivered to the radon detector.

## 2.2 Tower-Air Sampling

A diagram of the tower-air sampling system is provided in Figure 2-2. Air from the tower is pumped to the radon detectors at constant rates. For this function, air pumps associated with the various detectors are used. As described in Chapter 4,

the detectors that are used for this purpose are the WLM-30 (EDA Instruments, Inc.) and the TN-RG-20 (Thomson and Nielson Electronics, Inc.). Sample lines are multiplexed with a Scanivalve in much the same way as with ground-air samples.

The length of sample lines between the tower and the Scanivalve can be up to 20 meters (sample-line length may influence instrument sensitivities). Because this distance is fairly long, constant flow of air is maintained in the sample lines through the use of a third air pump connected to the tower-air Scanivalve common manifold. This is necessary due to the short half-life of radon and its daughters.

## **2.3 Manual Operation**

To use the RMC in the manual mode, the main POWER, the CPU, and the RUN switches on the front panel must all be in the up position (Figure 2-3). Under most circumstances, manual operations should not be attempted when the RMC is in RUN mode.

An external bank of five switches is provided for manual operations. The function of these switches may be better understood by consulting Figure 2-4. Scanivalves may be moved with the appropriate SCAN switch on the RMC control unit's front panel, Figure 2-3.

### **2.3.1 Scanivalves**

The position of Scanivalves may be changed by momentarily pressing the switch marked SCAN *n*, where *n* is a number from 1 to 4. SCAN 1 is for ground-air samples, SCAN 2 is for tower-air samples, and both the SCAN 3 and SCAN 4 switches are not functional at this time. (See Figure 2-3.) The position of the Scanivalves may be monitored by reading the analog voltage produced by each one.

### **2.3.2 The AIR Switch**

The AIR switch is used to turn on the air pump that is connected to the tower-air manifold. It is provided so that a constant flow of air is maintained in the tower-air sample lines when they are not connected to the detector.

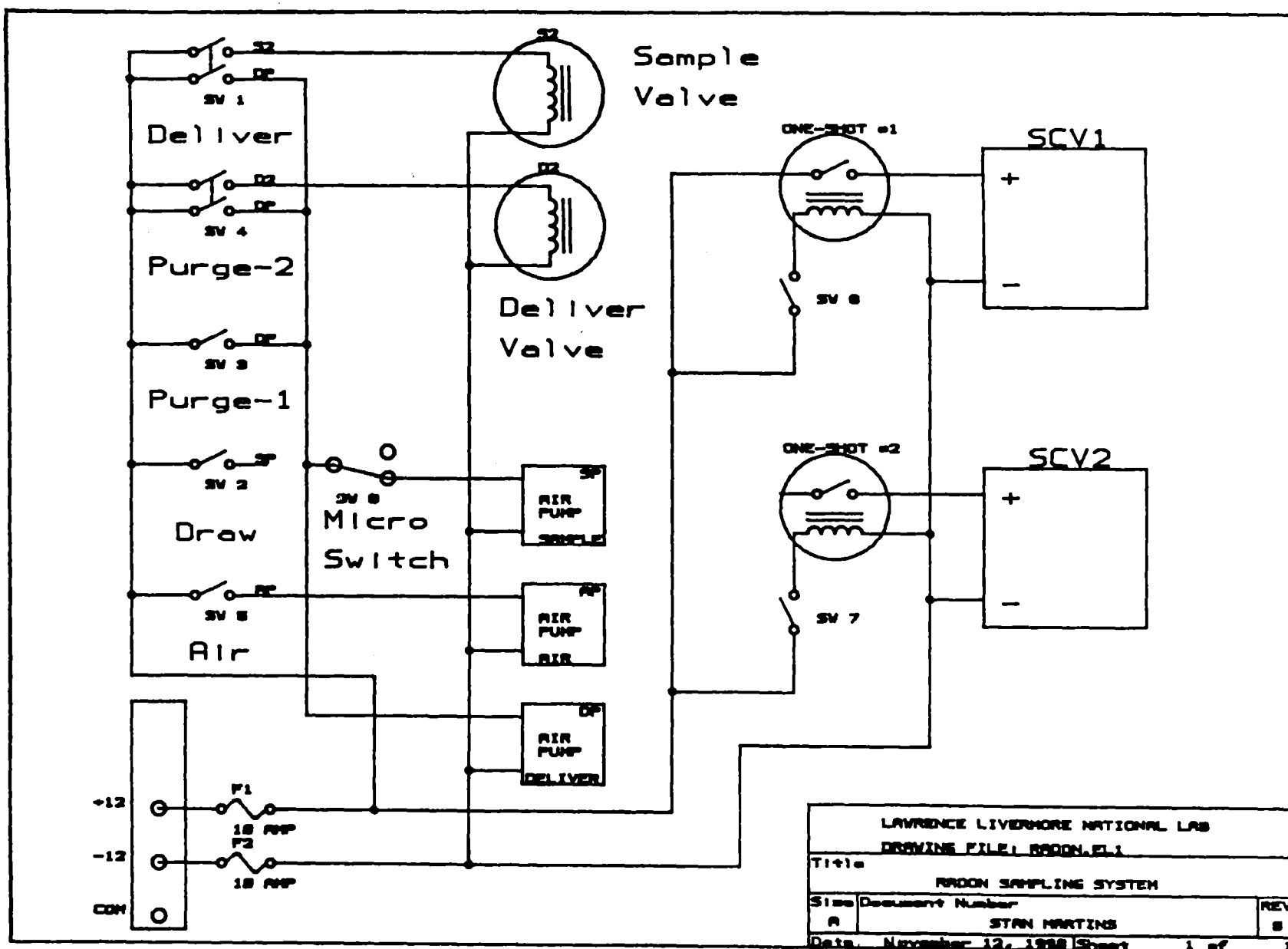


Figure 2-4. RMC Manual switch circuit.

### **2.3.3 The DRAW Switch**

The DRAW switch is used to fill the syringe with a sample of ground air. Neither of the PURGE switches nor the DELIVER switch may be on when DRAW is used. When this switch is thrown, the SAMPLE air pump is turned on, causing ground air to be pumped into the syringe. When the syringe plunger reaches micro switch 1 (Figure 2-4), power to the SAMPLE pump is turned off by the micro switch. At this point, the DRAW switch must be turned off.

### **2.3.4 The DELIVER Switch**

This switch is used to pump the ground-air sample from the syringe and deliver it to the radon detector. To do this, the DELIVER switch must perform two functions. First, it turns the SAMPLE 2-way valve so that air from the syringe may go to the detector. Second, it turns on the DELIVER air pump so that the syringe may be evacuated.

When the DELIVER switch is used, the DRAW switch and both PURGE switches must be open.

### **2.3.5 The PURGE-1 Switch**

The PURGE-1 switch is used to evacuate sample air lines and the Drierite (brand of anhydrous calcium sulfate) container (Figure 2-1). Basically, it pulls a vacuum on these parts so that prior samples will not interfere with subsequent samples. It functions simply by turning the DELIVER pump on.

When PURGE-1 is used, the DELIVER switch, the DRAW switch, and the PURGE-2 switch must be open.

### **2.3.6 The PURGE-2 Switch**

The PURGE-2 switch is used to purge the radon detector of the previous sample. As can be seen in Figures 2-1 and 2-4, the DELIVER 2-way valve is switched so that purge gas may be pumped by the DELIVER pump into the radon detector.

When PURGE-2 is used, the DELIVER switch, the DRAW switch, and the PURGE-1 switch must be open.

## 2.4 RMC Control Unit

The RMC control unit contains the system microprocessor, signal conditioning, the system clock, digital logic, and power-supply circuitry. It is connected to the RMC actuator unit by four cables. The analog, digital, and relay cables are attached to the front of the unit, as is shown in Figure 2-3. The power cable is connected to the rear of the unit. The 25-pin D connector labeled RS-232 may be connected directly to a laptop computer, which is used for control and data acquisition.

### 2.4.1 RMC Microprocessor

The microprocessor selected for this unit is a model SYS-2Z CPU by Octagon Systems, Inc. of Westminster, CO. It contains up to 8 KB of both RAM and ROM, 16 digital I/O ports, 1 serial port, and four 12-bit analog-to-digital converters. It contains its own programming language called OEM-BASIC. Code written for the SYS-2Z may be stored in one of its on-board EPROMs. Please consult section 2.5 for a description of this firmware.

Two of the analog converters are used to monitor the position of the gas-sample multiplexers (Scanivalves), one is used to monitor the +12-volt DC battery voltage, and the last is used to acquire data from an external instrument.

### 2.4.2 RMC Support Card

The RMC support card contains the system clock, reed relays to drive the Scanivalve one-shot timed relays, and the +5- and +12-volt DC power-regulation circuits. It is connected to the CPU card by a 44-pin bus and supplies the CPU with all of its power and the pulses for the CPU's real-time clock. Drawings of the circuits on the support card are presented in Figure 2-5.

The support card dip-switch settings are explained in Figures 2-6 and 2-7. Please note that firmware revision V.8, described in Section 2.4, expects clock pulses at 2 Hz. For additional clock settings, consult the product literature for the PX0-1000 oscillator package.

Switch SW-7 on the RMC support card must be on for the real-time clock to function. SW-8, EPROM power, should only be on when a new EPROM is being programmed.

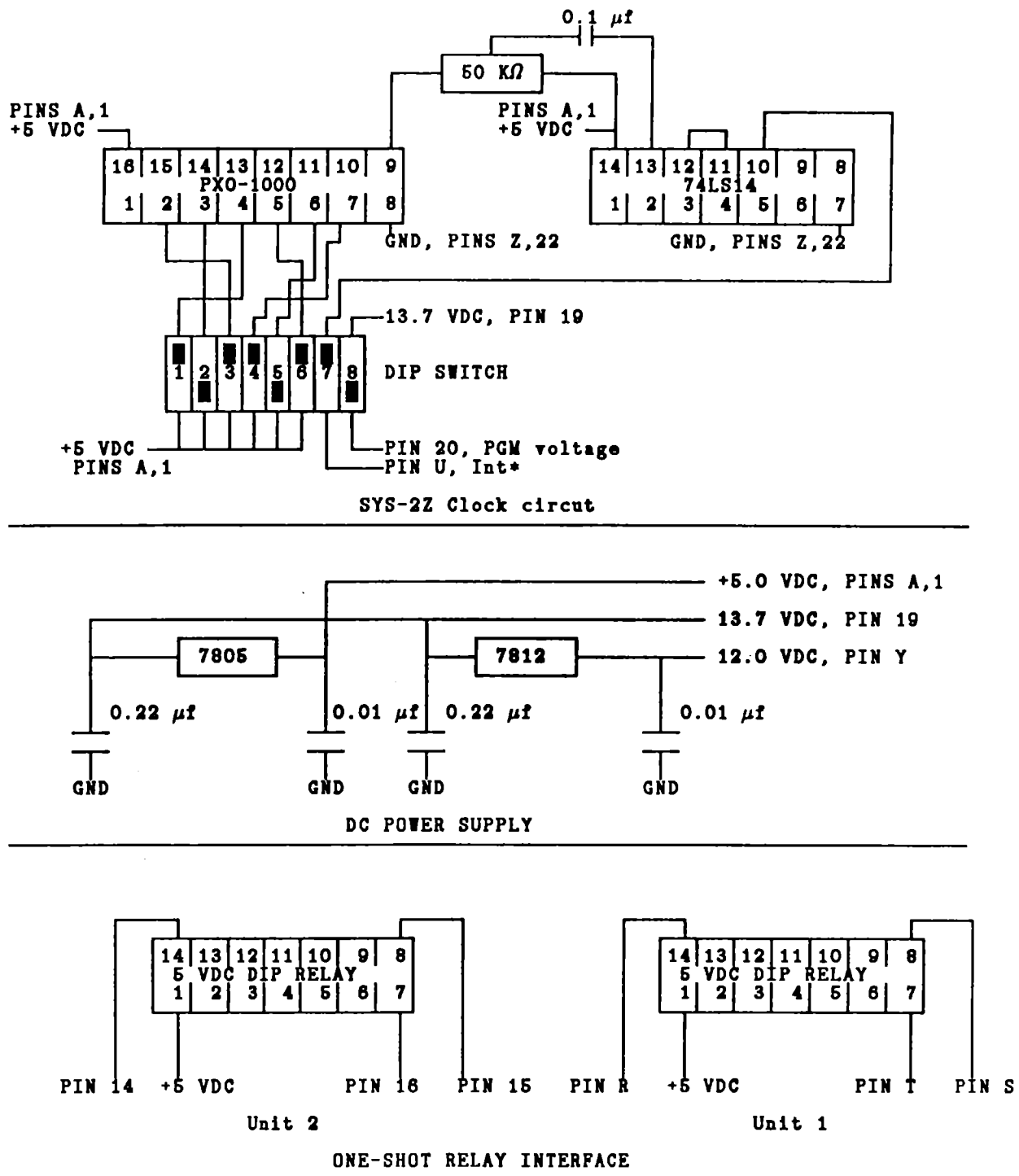


Figure 2-5. RMC support card circuits.

Switch	Function	Default	
		2 Hz	1 Hz
1	Clock P1	1	0
2	Clock P2	0	0
3	Clock P3	1	1
4	Clock P4	1	1
5	Clock P5	0	0
6	Clock P6	1	1
7	Clock Enable	1	1
8	EPROM Programming Voltage	0	0

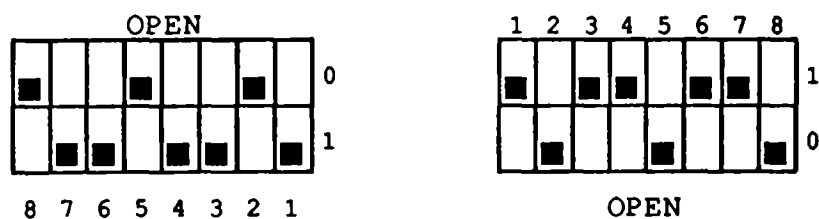


Figure 2-6. RMC DIP switch settings.

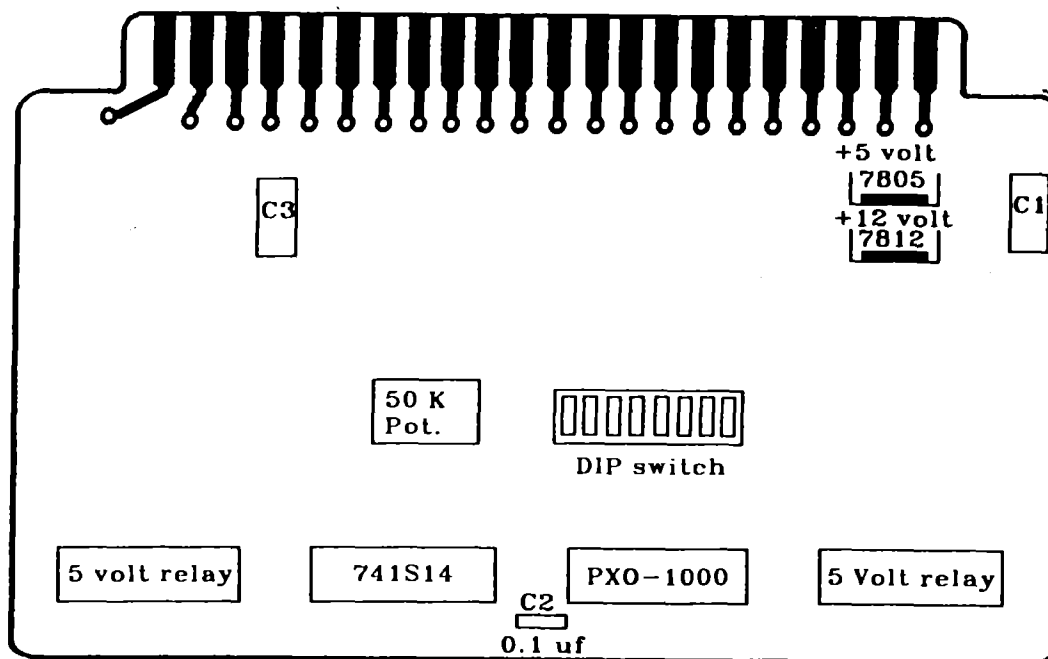


Figure 2-7. RMC support card layout.



### 2.4.3 RMC External Switches and Connections

Figure 2-3 shows the placement of front panel switches and cable connections. The connectors marked ANALOG, DIGITAL, and RELAY and the power connector in the rear of the unit must be connected by cables to the RMC actuator unit. The pin assignments for these cables are provided in Figures 2-8, 2-9, and 2-10.

The main power switch is located at the bottom center of the front panel and controls power to both the RMC control unit and to the RMC actuator unit. When the switch is placed in the up position, the unit is on.

When the switch marked RESET is turned to the up position, the CPU reset is on. This switch should be left in the down position except when required for EPROM programming. Consult the SYS-2Z manual<sup>(2-2)</sup> for its proper use. The CPU PWR switch must be in the up position if the CPU card and its power supplies are to function.

If the RUN switch is in the up position, the firmware resident on the CPU card will cause the program to enter the MENU mode. If the RUN switch is in the down position, the control sequence will start when power is applied to the CPU or when directed to do so from the MENU mode.

The switches labeled SCAN 1 through SCAN 4 are used to manually advance the Scanivalves in the RMC actuator unit.

The connector labeled RS-232 may be connected to a laptop computer so that system parameters may be changed in the MENU mode.

### 2.4.4 External Wiring Interface

The Thomson & Nielsen (T&N) radon detector is interfaced to the RMC control unit through the actuator unit. A description of the cable between the actuator unit and the TN-RG-20 is presented in Figure 2-11.

Wiring of the RMC actuator SSR relay block seen in Figure 2-12 is controlled through the Digital Cable, which is illustrated in Figure 2-10.

Pin	Name	Color	Description	Internal
A	+13.7-volt DC - INPUT	Orange	From battery	Switch
B	-13.7-volt DC - INPUT	Blue	From battery	Switch
C	Common	Green	From batteries	Common
D	+13.7-volt DC - OUTPUT	Red	To remote unit	Support
E	-13.7-volt DC - OUTPUT	Black	To remote unit	Not used

#### Main Power Receptacle

Pin	Name	Description
A	Common - ground	From support card PCLD-786
B	+ 5-volt DC	From support card PCLD-786
C	+12-volt DC	From support card PCLD-786
D	Unit 1 Scanivalve A	From support card to one-shot
E	Unit 1 Scanivalve B	From support card to one-shot
F	Unit 1 Digital input	From relay block, #8
G	Unit 2 Scanivalve A	From support card to one-shot
H	Unit 2 Scanivalve B	From support card to one-shot
J	Unit 2 Digital input	From relay block, #9
K	Menu/Run input	Digital input to flag CPU

#### Relay Receptacle

Figure 2-8. RMC power and relay cables.

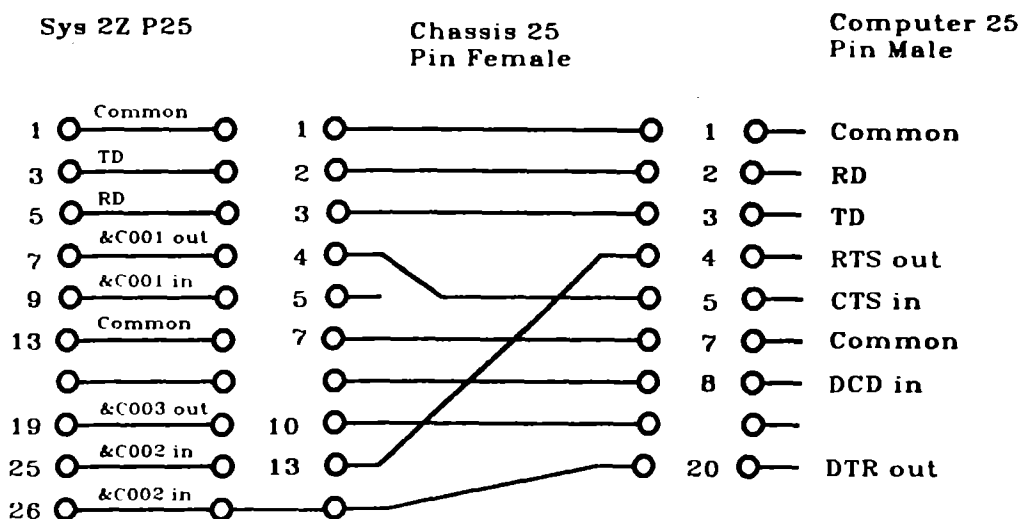


Figure 2-9. RMC RS-232 cable wiring.

### Front Panel 25-Pin Digital Plug

Pin #	Address	Description	DIN pin #
01	N.C.		1
02	&C00B	sample-2-way	3
03	&C008	Deliver pump	5
04	&C00D	Radon standard solenoid valve, air	7
05	&C007	Scanivalve one-shot #1	9
06	&C003	signal that ground sampling started	11
07	&C005		13
08	&C006	do not use - illegal	15
09	Ground		17
10	+5 VDC		19
11	&C009	Input Home-syringe	
12	&C00C	Input Menu/Run flag	
13	&C00D	Input	
14	&C00A	ground sample pump	2
15	&C00F	deliver-2-way	4
16	&C00C	Radon standard solenoid valve, ground	6
17	&C00E	Tower Air pump	8
18	&C002	Scanivalve one-shot #12	10
19	&C004		12
20	&C001	signal that tower sampling started	14
21	&C009		16
22	Ground		18
23	+12 VDC		20
24	&C00A	Input Full-syringe	
25	&C00B	Input	

### Front Panel 25-Pin Analog Receptacle

Pin #	Destination	Color
01		
02		
03		
04		
05		
06		
07		
08		
09	Ground	Green
10	+5 volts (out)	Red
11		
12		
13		
14		
15		
16		
17		
18		
19		
20	AD-3 T&N Radon Det.	White
21	AD-2 Scanivalve #2	Brown
22	AD-1 Scanivalve #1	Blue
23	AD-0 Battery Voltage	Black
24		
25		

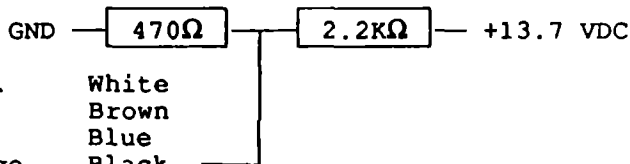


Figure 2-10. RMC analog and digital connectors.

T&N cable			Destination
Name	Color	Cable #	Name
+12-volt DC	Red	1	13.7-volt DC, from controller
Power ground	Black	2	Ground from controller
0- to 5-volt DC analog out	White	3	AD-3, 25 DB, analog cable
Analog ground	Black	4	Ground, 25 DB, analog cable
Analog reset +5-volt DC	Blue	5	PCL714, CN2, +5-volt DC
Analog reset GND VDC	Green	6	PCL714, CN3, CH11

Figure 2-11. Cable to T&N radon detector.

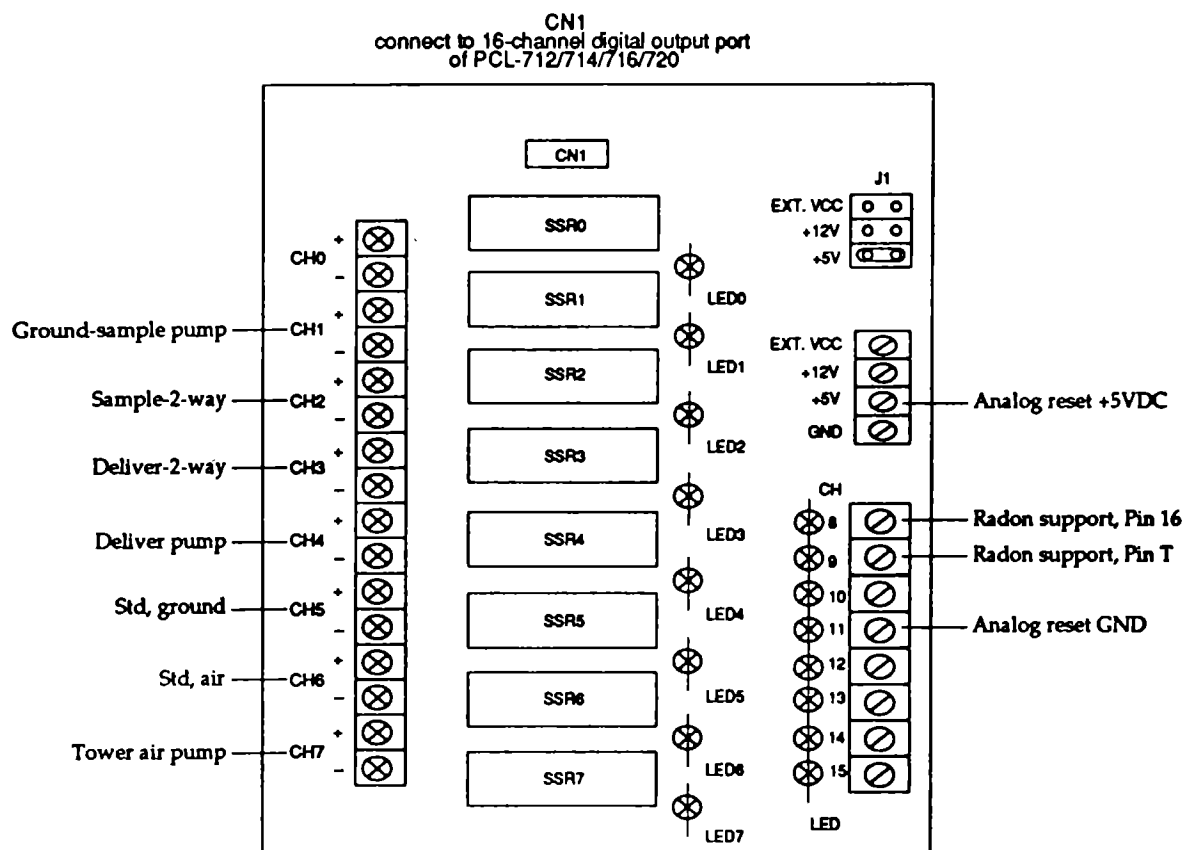


Figure 12. RMC actuator-unit relay block.

## 2.5 Firmware Description, Version V.8

The firmware for the RMC control unit was written in OEM-BASIC by the author. It may be operated in either a MENU mode or a RUN mode. The firmware has three primary functions. First, it sequences gas sampling for both ground and tower air. Second, it provides the logic for pulling a precise volume of ground-air sample at the correct time. Third, it logs analog data from the Thomson & Nielsen radon detector.

When the RMC's CPU is first powered up, the firmware will attempt to return both Scanivalves to position 1, or the HOME position. This may cause a slight delay in the start of a run if the RUN switch is in the down position when power is applied to the unit.

In the RUN mode, the firmware will cause up to 12 samples to be taken of both ground air and tower air per Scanivalve cycle. The starting Scanivalve position and last Scanivalve position of each cycle may be altered in the MENU mode.

Sampling is performed at regular intervals when the RMC is in the RUN mode. Sample times are regulated by the RMC real-time clock. This clock is external to the CPU board and communicates with the CPU by interrupts. The real-time clock does not run in the MENU mode.

### 2.5.1 MENU Mode

When power has been applied to the CPU and the RUN switch is in the up position, the menu shown in Figure 2-13 will be displayed if a laptop computer has been previously connected to the RMC control unit, and is running the proper communications software. The firmware revision number is printed at the end of the line beginning with "Menu Mode -".

Menu items may be selected by typing the letter in brackets at the beginning of each menu line. Most of these options allow the user to change system-default values. If the user is requested to enter more than one value, each value must be separated by commas.

**2.5.1.1 (B)egin/End Ground-Air Sampling.** When this item is selected, the user may enable or disable ground-air sampling when the next RUN is started. Type E <Enter> to enable or D <Enter> to disable. The default value is E.

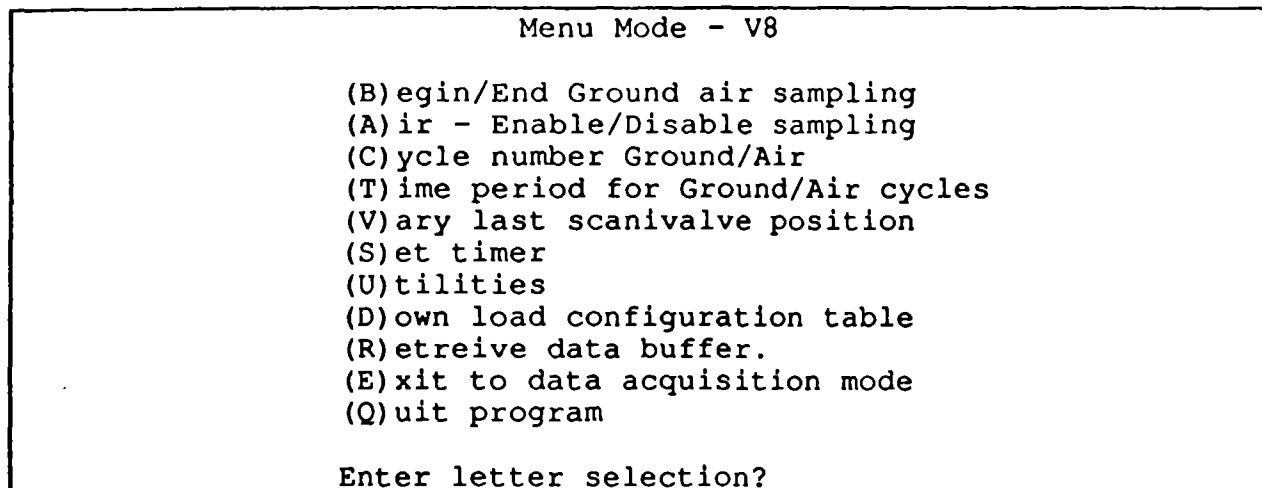


Figure 2-13: Firmware main menu.

**2.5.1.2 (A)ir - Enable/Disable Sampling.** When this item is selected, the user may enable or disable tower-air sampling when the next RUN is started. Type E <Enter> to enable or D <Enter> to disable. The default value is E.

**2.5.1.3 (C)ycle Number Ground/Air.** If this item is selected, the user must enter the step number or position for both Scanivalves at which the next RUN mode cycle will start sampling air. The default values are 1 and 1. Alteration of these numbers applies only to the immediate cycle. Subsequent cycles will start at step 1 for both Scanivalves.

**2.5.1.4 (T)ime Period for Ground/Air Cycles.** Three time periods must be entered in seconds if this menu item is selected. The default values are 1200, 600, and 1200. The first is the total time use by ground-air sampling. The second number is the amount of time the ground-air sample is held in the radon detector. The last number is the total time use for each tower-air sample.

It takes between 2 and 4 seconds for a Scanivalve to move from one channel to the next. Therefore, minor changes in the total cycle time per step may be required if the number of Scanivalve steps per cycle is different for ground and air samples. For example, if all 12 Scanivalve channels are being used for ground-air sampling, and only 4 Scanivalve channels are being used for tower-air sampling, a reduction of 6 or 7 seconds per tower-air step may be required to compensate for the time lost in skipping unused channels.

Firmware revisions may be required if radical changes in these settings are made.

**2.5.1.5 (V)ary Last Scanivalve Position.** This menu item allows the user to select the last Scanivalve position used by both ground-air and tower-air sampling. The default values for each are 12 and 12. It is often desirable to perform experiments where fewer than 12 sample lines are used, which is why this option was provided.

**2.5.1.6 (S)et Timer.** While the RMC control unit is in the RUN mode, the real-time clock is incremented by 0.5 seconds each clock pulse. This number can become quit large during the course of an experiment. Selecting this option allows the user to set the start point of the clock at whatever value is desired. The default value is 0 and is read in elapsed seconds.

**2.5.1.7 (U)tilities.** This item should not be selected by most users. It redefines the interrupt address of the RUN/MENU switch. If the wrong value is selected, the firmware will not return to the MENU mode when the RUN switch is toggled up. The default value is 3. If 2 is selected, the DTR line on the serial cable may be used to control the RUN/MENU mode.

**2.5.1.8 (D)own Load Configuration Table.** If experiments that require many of the default values to be changed are performed on a regular basis, the user may avoid selecting the previous menu items by writing all of them into a file that can be down loaded to the RMC control unit. The file should be written in the format shown at the bottom of Figure 2-14. When D is selected, transfer this file to the RMC from the laptop with communications software. Be sure to use pauses between characters and lines, because the SYS-2Z reacts very slowly to inputs from its serial port.

**2.5.1.9 (R)etrieve Data Buffer.** When the firmware is in the RUN mode, data from analog-to-digital (A/D) converter's channel 3 is stored a circular data buffer every 60 seconds. The data is an average of 60 readings and is stored as A/D units.

Bulk variables	Defaults
TS = tower air enable=0, disable=1	TS=0
GS = ground air enable=0, disable=1	GS=0
C1 = cycle number for ground air	C1=1
C2 = cycle number for tower air	C2=1
SS = Master clock seconds	SS=0
GT = Ground cycle seconds	GT=1200
GM = Ground air sample time	GM=600
AT = Tower air sample time	AT=1200
I = Interrupt address (1-16) + 49152	I=49155
MG = Last Scanivalve position for ground air	MG=12
MA = Last Scanivalve position for tower air	MA=12
Sample Variable File containing all defaults	
0 , 0 , 1 , 1 , 0 , 1200 , 600 , 1200 , 49155 , 12 , 12	

Figure 2-14. RMC system defaults and down-load file format.

Currently these data are from the Thomson & Nielsen TN-RG-20 radon detector and represent cumulative counts over a given period of time. A change of 1 A/D unit represents one alpha count detected by the detector. Because the sensitivity of this instrument is 4.72 cph/pCi/L, a change of 4.72 A/D units in one hour equals one pCi/L.

**2.5.1.10 (E)xit to Data-Acquisition Mode.** When the RUN switch is in the down position, and R is selected from the Main MENU, the firmware will leave the MENU mode and start a data-acquisition cycle.

**2.5.1.11 (Q)uit Program.** Selecting Q from the Main MENU will cause the firmware program to terminate and to enter OEM-BASIC interpretative mode. If this is done inadvertently, it is possible to re-enter the program by typing CONT <Enter>. If this does not work, try typing GOTO 17000 <Enter>.

If the program has ended, and one wishes to restart it with all of the system defaults in place, simply type RUN <Enter>.



## 2.5.2 RUN Mode

The RCM firmware will automatically start in the RUN mode if the RUN switch is in the down position when the power to the CPU is turned on. When this happens, the default parameters listed in Figure 2-14 will be used during the run. If an alternate set of parameters is desired, procedures in section 2.5.1 must be used.

While the firmware is in the RUN mode, no commands from the keyboard of the laptop computer will be accepted. Stray key hits may actually cause the firmware program to stop. If this happens, type `ON ITR GOSUB 10000:CONT <Enter>`. If this does not work, try typing `GOTO 34 <Enter>`.

**2.5.2.1 Run Time Display.** Data is constantly printed to the laptop computer when the RCM is in the RUN mode. These data include the current RUN time in seconds, time until the next event, and the position of Scanivalves 1 and 2 in A/D units. The correlation of A/D units to Scanivalve position may be seen in Figure 2-15. Please note that a low, nominal, and high value is given for each position. If a reading is less than the low value or greater than the high value, then the Scanivalve position is assumed to belong to another position. If the A/D reading does not appear on the chart, then a hardware problem exists and this must be corrected. Every thirty seconds, the battery voltage of the positive supply and the current T&N cumulative count in A/D units will be printed at the end of the data line. A typical data line would look like this:

93477 128 357 2460 13.7 605

In this example, the firmware has been in the RUN mode for 93477 seconds, the next event will occur in 128 seconds, Scanivalve 1 is in position 2, Scanivalve 2 is in position 8, the battery voltage is 13.7, and the T&N Radon detector has received radon counts equivalent to 605 A/D units.

## 2.6 RUN Mode Events

Two semi-autonomous master cycles occur in the RUN mode. The first governs ground-air sampling and the other governs tower-air sampling. Both are driven by the system real-time clock and are dependant on Scanivalve position. The basic intent of the RUN mode is to automate the manual sequences described in section 2.3.

Position	A/D units		
	Low	Nominal	High
1	0	0	100
2	250	350	450
3	600	700	800
4	950	1050	1150
5	1300	1400	1500
6	1650	1750	1850
7	2000	2100	2200
8	2350	2450	2550
9	2700	2800	2900
10	3050	3150	3250
11	3400	3500	3600
12	3750	3850	3950

Figure 2-15. Scanivalve position in A/D units.

### 2.6.1 Common Events

Both cycle types must keep track of Scanivalve positions and change them at the appropriate time. When the RUN mode is entered, the firmware checks each Scanivalve position and adjusts it if the Scanivalve is not in the correct position. The start time for the run is determined, and each sample cycle is started.

At the end of each data-acquisition cycle, the Scanivalve position is advanced by the firmware to the next position. If unused positions on the Scanivalve are encountered, the firmware will advance to the first position. The ground-air sampling routine will cause the Scanivalve to advance immediately after its purge cycle. The tower-air sampling routine must wait until the master cycle is finished before this occurs.

### **2.6.2 Ground-Air Sampling Events**

If the Scanivalve is in the correct position for the next ground-air sample, a 300-mL sample of air will be drawn from the ground-air sampling port. It will then be injected into the radon detector, where it will be held for a counting period of 10 minutes. At the end of this time, the firmware will go through the two purge cycles, which are described in section 2.3. When this is complete, the Scanivalve position will be advanced, and the firmware will wait until the beginning of the next ground-air cycle.

### **2.6.3 Tower-Air Sampling Events**

Of the two cycle types, tower-air sampling is the simplest and consists of one event. This is the advance of the Scanivalve. When the cycle time has elapsed, the Scanivalve will be advanced to the next valid position.

### **References**

- 2-1. Rose, Arthur W., John W. Washington, and Daniel J. Greeman (1988), "Variability of Radon with Depth and Season in a Central Pennsylvania Soil Developed on Limestone," *Northeastern Environmental Science* 7(1), 35–39.
- 2-2. Octagon Systems, Inc. *OEM Bus User's Manual*. SYS-2Z Single Board Control Computer. Octagon Systems, Inc., Westminster, CO.



## 3.0 Communication-Software Description

Several of the instruments described in this document require communication with computers. Software is available for use on MS-DOS laptop computers that satisfies these requirements. All of these programs communicate with the peripheral instruments through the computer's RS-232 serial port. Some of the programs are multi-purpose, while others are written specifically for a single instrument.

### 3.1 RADCON.EXE

This program was written by the author to communicate with both the Radon-Monitor Controller (RMC) control unit (Chapter 2) and with the WLM-30 multi-channel analyzer and radon detector (Chapter 4).

Once the laptop computer is connected to either of the instruments, the program may be started with or without arguments. If no argument is to be used, the user will type

RADCON <Enter>.

When no arguments are used to invoke the program, the default serial port will be COM1. Data-logging files will be written to the current disk drive.

When the program starts, a menu similar to the one shown in Figure 3-1 will be displayed regardless of the argument(s) used. Please notice that the first line of the display contains a version number for the software, a mode statement (either WLM30 or Radon Con), the Julian date, the current real time, and the number 0. The 0 indicates that data logging is not enabled. When this number is 1, data logging has been enabled. The WLM30 flag on the top line indicates that RADCON expects to communicate with a WLM-30 instrument. By pressing the <F2> key, this flag will be replaced with "Radon Con" and the program will be configured for the RMC.

An alternate configuration may be specified by the use of arguments when the program is invoked. For example if the user were to type

RADCON 2 <Enter>.

the program would use COM2 and log data to the current disk drive. If the user were to type

RADCON 1 A: <Enter>.

the program would use COM1 and log data to disk drive A. If an alternate data-logging drive is desired, the program must be invoked by stating the serial port

```
Version: 1.1                                WLM30    302 12:34:54
0

1WLM30  2RMC   3HELP  4LogDat  5Status  6      7      8      9      10Quit
```

Figure 3-1. Main menu screen of RADCON.

desired followed by the disk drive, as in the last example, even though the user wishes to use the default port COM1.

The user may select the RMC mode over the WLM30 mode by typing

RADCON 2 B: 1 <Enter>.

Three arguments are required here, with the last being 1. In this example, COM2 is selected, data will be logged to drive B: and Radon Con will be printed on the top line of the display to the left of the time string in place of the WLM30 as shown in Figure 3-1.

### 3.1.1 Function Keys

The function keys, which are labeled and appear at the bottom of the screen (see Figure 3-1), are programmed to allow the user to communicate with the program. Striking any other key will cause a message to be sent to the remote instrument.

The <F1> key will configure the program to communicate with the WLM-30.<sup>(3-1)</sup> This will select a baud rate of 9600, no parity, an 8-bit data word, and 2 stop bits. When <F1> is pressed, data logging is automatically disabled.

@=Get pump status	M=Returns 210
<=Stop program	O=Get current information
>=Start program	P=Get spectrum window summary
A=Store all data	Q=Get windows, set if pair sent
B=Get status	R=Last data spectrum
C=Store Counts	S=Total spectrum
D=Store data	W=Get working level readings
E=Get error codes	Y=Get scount data
F=Send interval, start/stop time	^1= BT - Report filter status
G=Get current program status	^2= BF - Turn on pump/report
L=Last data	

Figure 3-2. RADCON help menu for WLM-30 operations.

The <F2> key will configure the program to communicate with the RMC control unit. This will select a baud rate of 4800, no parity, an 8-bit data word, and 1 stop bit. When <F2> is pressed, data logging is automatically disabled.

The <F3> key will display the help menu that is shown in Figure 3-2 when the software is in the WLM30 mode. When some of these commands are typed from the keyboard, dual actions will result. For example, when F is typed in the WLM30 mode, the current time on the computer will be used to set the WLM-30's internal real-time clock. If D is typed, all data from the WLM-30 will be requested and logged to the computer's disk drive as it is received.

Pressing the <F4> key will toggle the data-logging state from on to off or off to on. When data logging is on, data will be stored on a disk and the number to the right of the time on the first line of the display will be 1. Conversely, this number will be 0, and no data will be logged if data logging is toggled off.

If the <F5> key is pressed, the current status will be displayed. This includes the serial port configuration (i.e., port number and baud rate) and the name of the data-logging file, if data logging is enabled.

To quit the program, press <F10> Y <Enter>.

### 3.1.2 Program Features

When the program is running, most key strikes on the laptop keyboard will be echoed to both the serial port and to the computer's screen. Stray key strikes sent to either of the instruments may have undesirable results, so the user should

exercise care when this program is running. The user should refer to section 2.3.2 in regard to this matter.

All characters sent by the remote instrument to the computer's serial port will be echoed to the laptop's screen. If data logging is enabled, these characters will also be stored on the disk drive.

### **3.1.3 WLM30 Mode.**

This mode may be selected by pressing <F1>. The message to the left of the Julian date on the top line of the computer's display will say WLM30. As mentioned above, a help menu may be requested by pressing <F5>. Many of the WLM-30 commands will be displayed there.

Using the F command when the WLM-30 has been toggled to ON will allow the user to avoid performing all of the setup functions in section 3.3.1, below.

Using the O command when the WLM-30 has been switched to the AUTO mode will allow the user check the memory status, and all of the TIME WLM-30 parameters.

Data logging may be toggled on by pressing <F4> or by typing the letter D. This will cause the number at the right of the time string, on the top line of the display, to switch from 0 to 1. If <F4> is selected, the reports sent automatically by the WLM-30 at the end of each sample period will be received and logged to disk. If the letter D is used to initiate data logging, then all of the data in the WLM-30's memory will be logged onto the computer.

Some hand shaking between the computer and the WLM-30 is required if communications are to take place. This protocol uses a log-on string to initiate communications and XON/XOFF at the start and end of each subsequent line. All of this support is provided by RADCON. Due to this requirement, programs like MEX-PC, below, may not work for the acquisition of data from the WLM-30.

### **3.1.4 RMC Mode.**

This mode may be selected by pressing <F2>. The message to the left of the Julian date on the top line of the computers display will say Radon Con. As mentioned above, nothing will happen when <F5> is pressed.

Data logging may be toggled on by pressing <F4>. This will cause the number at the right of the time string, on the top line of the display, to switch from 0 to 1.



The data-logging feature of RADCON is used to store near real-time data from the RMC control unit when it is in the RUN mode. Because the RMC prints data to the computer almost constantly, RADCON selects a data string every 60 seconds and logs it to the disk with a time stamp. The string is selected on the basis of the length of the string. Due to this feature, RADCON should NOT be used to save the RMC's internal buffer when the RMC is in the MENU mode (see section 2.5.1.8). A program like MEX.COM should be used for this purpose.

## **3.2 MEX.COM**

MEX.COM is a customized version of MEX-PC. MEX-PC stands for the Modern Executive Communications Software program for Personal Computers. If the user wishes to become proficient in the use of this program, the MEX-PC<sup>(3-2)</sup> manual should be consulted. A limited command set is given below.

MEX.COM may be used to communicate with the HANDAR 540A, the RMC control unit, the AIR-DB barometer, and, to a limited extent, the WLM-30. Each of the peripherals require their own communications protocols.

### **3.2.1 Running the Program**

MEX.COM may be started with or without arguments. In the simplest case, the user need only type

MEX <Enter> .

The program will run and enter the command mode with the default environmental parameters that MEX.COM was cloned with. For other invocation arguments, consult the MEX-PC manual.<sup>(3-2)</sup>

### **3.2.2 MEX Commands**

From the command mode, SET may be used to change the program parameters.

SET BAUD 4800 <Enter>. The values 300, 1200, 2400, 4800, 9600, or 19200 are allowed. Use 300 for the HANDAR, 4800 for the RMC, and 9600 for the WLM-30.

SET WORD 8 <Enter>. Either 7 or 8 bits are allowed. Use 8 bits for both the WLM-30 and the RMC and 7 for the HANDAR unit.

SET PARITY NONE. <Enter>. ODD, EVEN, or NONE are allowed. Use NONE for both the WLM-30 and the RMC, and EVEN for the HANDAR unit.

SET STOP 2 <Enter>. Either 1 or 2 bits are allowed. Use 2 bits for both the WLM-30 and the RMC, and 1 for the HANDAR unit.

Type T <Enter> from the command mode to get into the interactive mode.

From the command mode, type TERMA filename.ext <Enter>, T <Enter> to save data from the peripheral instrument onto a disk. The filename.ext should be replaced with the file name and extension that is to be used with the disk file. After the data have been received, press the <Home> key and type WRT <Enter> to save the data to the disk file.

Press the <Home> key to leave the interactive mode and return to the command mode.

From the command mode, type DOS <Enter> to quit the program.

### 3.3 WLM30.EXE

This program was provided as an uncompiled BASIC program called RTAIBM.BAS with the WLM-30 instrument by Scintrex/EDA of Ontario, Canada. It was modified and compiled by the author to allow for the selection of COM port and data-logging disk drive at invocation.

This program is described in the RTA-30 manual.<sup>(3-1)</sup> It uses a hierarchical menu structure that the user should be able to follow with little difficulty.

To start the program, toggle the WLM-30's front panel switch to either ON or AUTO and type

WLM30 1 B <Enter> .

The 1 indicates COM1 is to be used, and B indicates that disk drive B is to be used for data logging. If no arguments are used, the program defaults to the default drive and the COM1 serial port.

#### 3.3.1 WLM-30 Setup

The following instructions should be followed if the F command was not used from RADCON in section 3.1.3, above.

The WLM-30 will not acquire data after its internal memory has been filled with data, so the unit must be instructed to erase the memory after those data have been retrieved, but prior to the start of a new run. This is done by toggling the WLM-30's front panel switch to ON. Select <F1> PROGRAM, <F6> MEMORY ERASE and type Y <Enter>. When the WLM-30 starts its next acquisition cycle, the memory will be erased. This must be done every time a new run is started to ensure that old data will be erased.

While still in the PROGRAM menu, select <F2> SET TIME. Press <Enter> to accept the default values. This will transfer the computer's real time to the WLM-30. If different times are required, they may be entered at the prompts.

Pressing <F10> from most menus will return the user to the MAIN menu.

### 3.3.2 Data Retrieval.

Data may be retrieved from the WLM-30 in a variety of different formats. In these experiments, total DAUGHTERS are used. From the MAIN menu, select <F2> READ. Now select <F7> STORE DAUGHTERS. If a different drive than is specified in <F2> is desired, select <F2> and enter the new drive. Select <F1> and type in the file name that the data are to be stored under. When <F10> is pressed, the WLM-30 will send all of its data to the computer, where they will be stored on disk.

## References

- 3-1. Scintrex/EDA (1989), *RTA-30/IBM-PC Interface Operators Manual*, Scintrex/EDA, Ontario, Canada.
- 3-2. Fixmer, Rob (1986), *MEX-PC Users Manual*, NightOwl Software, Inc., Fort Atkinson, WI.



## 4.0 Radon Detectors

A variety of commercially available radon detectors can be used with this system. Each has its own capabilities and functions.

### 4.1 WLM-30 Detector and Multi-Channel Analyzer.

The WLM-30 is produced by Scintrex/EDA of Ontario, Canada. It is a self-contained unit that provides an air pump, radon detector and multi-channel analyzer (MCA) in one unit. A description of this unit may be found in the operators manual.(4-1)

The MCA has a resolution of 1 channel in 256 over the energy spectrum that is occupied by radon and its daughters. Up to six unique or overlapping windows that contain all or part of the 256 channels may be programmed into the WLM-30. The WLM-30 used in this experiment was modified at the factory with two ports that accept TTL signals from the two RD-200 radon-detector units described below. A window was programmed in the MCA for each of the RD-200s. The distribution of these channels is presented in Figure 4-1. Please be aware that each of the RD-200 units is slightly different, and each must be plugged into its own port on the WLM-30.

The windows settings in Figure 4-1 may be altered by using the PROGRAM menu in WLM30.EXE.(4-1)

WLM-30 label	Start	End	Description
RaA	129	143	Polonium-218 (Radium A)
RaC'	165	199	Polonium-214 (Radium C')
ThA	155	169	Polonium-216 (Thorium A)
ThC	236	245	RD-200 240 detector
ThC'	246	255	RD-200 250 detector
Total	0	234	All Non RD-200 counts

Figure 4-1. Window settings for WLM-30 multi-channel analyzer.

#### **4.1.1 WLM-30 Operations**

The WLM-30 may be powered by an external 12-volt battery or by 120-volt AC. On the front panel, there is a three-way toggle switch that controls power to the unit. These positions are ON, OFF, and AUTO.

In the OFF position, the unit is off but its memory is maintained by an internal battery.

If the unit has been properly programmed through the use of either RADCON or WLM30 . EXE, a data-acquisition cycle will begin on the next even minute after the toggle switch has been placed in the AUTO position. Data acquisition will continue until the switch setting is changed, or until the WLM-30's memory has been filled or the WLM-30's stop time has been reached.

When the front panel switch is in the ON position, the WLM-30 may be programmed, data may be retrieved, or a data-acquisition cycle may be started.

The only way to communicate with the WLM-30 is with a IBM-compatible personal computer via an RS-232 serial interface. The personal computer must run an appropriate communications-software program. Three of these programs are described in Chapter 3.

The WLM-30 was not designed to pull an air sample from a remote source. As can be seen in Chapter 2, Figure 2-1, this unit is used to sample air from a tower some distance away. To facilitate this sampling scheme, a manifold was constructed that fits over the WLM-30 sample port. After a quarter-inch hose barb was installed in the manifold, the WLM-30's internal pump was able to draw tower air through a quarter-inch Tygon tube to the radon detector at 1.0 liters per minute.

#### **4.1.2 WLM-30 Maintenance**

The sample port on this unit contains a sub-micron filter, which is required for the radon detector to function. It must be replaced from time to time when the filter loading becomes too great, or background readings are excessive.

#### **4.1.3 WLM-30 Calibration**

A radiation source is provided with this unit for calibration. To calibrate the unit, use a pair of tweezers to replace the sub-micron filter in the sample port with the radiation source. Data that can be used to check the sensitivity of the detector

can then be collected in the usual way. When finished with the calibration, replace the source with a new filter.

## **4.2 RD-200 Detector**

The RD-200 radon detector is produced by EDA Instruments Inc. of Toronto, Canada. It was originally designed to be completely portable, but was factory modified to interface with a special cable to the WLM-30 unit described in section 4.1. This cable transmits, as TTL pulses, all disintegrations detected by the RD-200's photomultiplier tube to the WLM-30. When 120-volt AC power is available, the WLM-30 uses this cable to supply power to the RD-200.

For a detailed description of this unit consult the operations manual.<sup>(4-2)</sup>

### **4.2.1 RD-200 Operations**

The front panel of the RD-200 contains three switches. The first is the power switch and should be placed in the external mode when the RD-200 is being used with a WLM-30 that is connected to hard power. When toggled to internal, power will be drawn from the internal alkaline batteries. The second is the SAMPLE switch. This must be toggled ON if the unit is to count the sample in its sample chamber. The user can verify that this is on by observing the LED display on the front panel. If the SAMPLE switch has been toggled on, the count on this display will increase from time to time. Pressing this switch a second time will toggle sampling off. The third switch is the display switch. This is only active if the internal batteries in the RD-200 are used for power. Pressing this switch will toggle the LED display on and off.

Please be aware that the RD-200 to WLM-30 interface cable has a plug at both ends and carries a constant +12-volts DC, even when the WLM-30 is turned off. Therefore, care should be taken not to short these plugs when they are not connected to the RD-200.

The energy window of each RD-200 is a little different, so the user must be sure that each RD-200 unit is connected to its own port on the WLM-30 unit.

### **4.2.2 RD-200 Maintenance**

There is little to maintain here. One should keep track of the performance of the counting chambers. If the residual counts stay high over a period of days, then the chamber should be replaced (consult the manual<sup>(4-2)</sup> for the replacement procedure). In addition, if the sensitivity of the chamber is reduced below acceptable levels, then the counting chamber should be replaced.

### **4.2.3 Calibration**

Two special counting chambers, each containing a radioactive source, were provided with the RD-200 units. One source has twice the activity of the other. When these sources are installed in each of the RD-200s, calibration data can be acquired by the WLM-30 unit. In addition to use as a sensor calibration of the RD200s, these data may be used to check the energy-window settings of the WLM-30. If, after running a spectrum with WLM30 .EXE, the energy spectrum of either of the RD-200 units is found to fall outside of the pre-programmed window, reprogram these window settings and acquire more calibration data.

## **4.3 TN-RG-20 Radon Detector**

The TN-RG-20 radon detector is produced by Thomson & Nielsen Electronics, LTD. of Ottawa, Canada. It contains a sample-delay loop consisting of a coil of copper tubing with a filter at each end. The first filter eliminates particles from the counting chamber so that only radon daughters formed in the delay loop will reach the sensor. Theoretically, sensitivity is increased because the post-filter will collect more daughters than a similar instrument with a shorter sample path. The post-filter is in close proximity to the unit's solid-state detector, where the daughters are counted as they disintegrate. For more details consult the manual.<sup>(4-3)</sup>

The TN-RG-20 requires a 12-volt DC power supply and has two different kinds of signal output. The first is a TTL level pulse, which is sent whenever a disintegration is detected. The second type is an analog output with a signal level of 0 to 5 volts. The analog signal will increase at the rate of 5.76 mV/hr/pCi/L. When the signal reaches 5 volts, no further change is possible. The reset switch on the unit will set the analog output back to 0. The analog reset may also be performed by an external computer.



#### **4.3.1 TN-RG-20 Operations**

Before operating the TN-RG-20, be sure that the delay column is connected to the detector unit via a piece of Tygon tubing. Turn the power and pump switches on and check the air-flow rate. If it is not 2.0 liters per minute, adjust the internal regulator.

When the optional analog output is being used, be sure to use the analog reset switch at the beginning of an experiment and whenever the signal level reaches 5 volts.

The Thomson & Nielsen data module may be connected to one of the TTL outputs of the TN-RG-20 units, if data are to be acquired in this way.

In some experiments, an RD-200 unit is connected between the TN-RG-20 and the tower. In this configuration, a 5-micron pre-filter is placed on the input side of the RD-200 and the pre-filter is removed from the TN-RG-20.

#### **4.3.2 TN-RG-20 Maintenance**

This unit contains a 5-micron pre-filter at the head of the delay column and special post-filter in the counting chamber. Both are required for the radon detector to function. These filters must be replaced from time to time when the filter loading becomes too great, or background readings are excessive.

The internal air-flow regulator may be adjusted with a screw driver if the air-flow rate is not 2.0 liter/minute. This is accessible from the front panel.

#### **4.3.3 TN-RG-20 Calibration**

A radiation source is provided with this unit for calibration. To calibrate, replace the special post-filter assembly in the sample chamber with the radiation source. Collect data in the usual way, and use the data to check the sensitivity of the detector. When finished with the calibration, replace the radiation source with the filter assembly and a new filter.

#### **4.3.4 TN-RG-20 Data Acquisition**

Data may be acquired from the TN-RG-20 unit in two ways. The first is by connecting the analog port of this radon detector to the RMC control unit as

described in Chapter 2. Communications software such as RADCON.EXE or MEX.COM can be used to log the data onto a laptop computer, as described in section 3.1. The second way is through the use of the Thomson & Nielsen TN-DU-01 data module. If the latter method is used, a software program called 2100-01 must be used to retrieve the data. This software is menu driven and fairly easy to use. No description will be provided here.

### References

- 4-1. Scintrex/EDA (1989), *RTA-30/IBM-PC Interface Operators Manual*, Scintrex/EDA, Ontario, Canada.
- 4-2. EDA Instruments Inc., *Operation Manual, RD-200 Portable Radon Detector & RDU-200 Radon Degassing Unit*. EDA Instruments Inc., Toronto, Canada.
- 4-3. Thomson & Nielsen Electronics, LTD., *TN-RG-20 Radon Monitor Operating Manual*, Thomson & Nielsen Electronics, LTD., Ottawa, Canada.

## 5.0 AIR-DB Software and Hardware Description

The AIR-DB digital barometer was selected for these experiments because of its rapid sample rate of up to 10 Hz and its ease of interface with computers. It is manufactured by Atmospheric Instrumentation Research, Inc., of Boulder, CO.

The software program called AIR-DB.EXE was written by the author to be used on a laptop computer to acquire and log the average and standard deviation of pressure at regular intervals from the AIR-DB barometer. The barometer itself will not store more than one data reading at a time, so the barometer must be connected to a laptop computer that is running the AIR-DB software.

The barometer contains a bank of internal dip switches that may be set to change the sample interval, the baud rate of its serial port, and the pressure-data reporting format. The value of these settings must be reflected in AIR-DB.CFG (Figure 5-1).

The barometer averages pressure readings internally until its sample period has elapsed. If the DTR line on the serial port is high, the current pressure average is sent to the serial port as ASCII data. AIR-DB.EXE receives these data and uses them for the current mean and standard deviation calculation.

### 5.1 Software Initialization

When AIR-DB.EXE is first run, it reads a file called AIR-DB.CFG, which contains most of the system variables that are needed by the program. An example of this file is presented in Figure 5-1. Please note that only lines 4 through 6 in Figure 5-1 pertain to Air-DB barometer data acquisition.

Line	Configuration data	Explanation
1.	COM1	First Serial Port
2.	1200	First Baud Rate
3.	,N,8,1,CS0,DS0,CD0,RS,BIN	First Communication Parameters
4.	COM2	AIR-DB Serial Port
5.	9600	AIR-DB Baud Rate
6.	,N,8,1,CS0,DS0,CD0,BIN	AIR-DB Communication Parameters
7.	300 3000	Seconds per averaging period, Maximum number of samples

Figure 5-1. Sample AIR-DB.CFG file.

The first value on line 7 is 300. This means that every 300 seconds the program will compute a new mean and standard deviation of pressure. The second number, 3000, is the maximum number of readings the program will accept over this period. If 3000 pressure readings are received by the program before 300 seconds have elapsed, the program will compute and log the mean and standard deviation, clear itself of the old data and start completing a new set of values.

If the file `AIR-ID.CFG` is present on the default disk drive, it will be read when the program starts. Its data will be included in the header for each new data file. An example of this file would be:

2, 60, 61.

The 2 indicates that the AIR-DB barometer is station 2 in a network of instruments. Station 1 in the network is the HANDAR 540A (described in Chapter 6). Station 2 reports will contain data from 2 channels. Channel 60 is the mean of pressure readings, and channel 61 is the standard deviation of pressure.

## 5.2 Running the Program

From the DOS prompt, type `AIR-DB <Enter>`. The program will start to print pressure readings to the laptop-computer's screen. At the end of the data-acquisition period described in section 5.1, the mean and standard deviation of pressure will be stored on the current disk drive.

## 5.3 AIR-DB Command Set

There only two commands the `AIR-DB.EXE` program will accept. They are as follows:

- **Quit** - `AIR-DB.EXE` may be terminated by pressing the `<ESC>` key.
- **Transfer Data** - If the `<A>` key or the `<B>` key is pressed (capital letters), then the current data file will be transferred to the disk drive with that letter.

## 5.4 Data Logging

As long as the AIR-DB barometer is functioning, pressure means and standard deviations will be calculated by the program and logged to a disk file. The file names are assigned by the program each day using the following format,

BARyyjjj.DAT

where yy is the year and jjj is the Julian date. If the program is run for more than one day, a new file name will be created at midnight.

Each data file starts with a header on the first line. For example, the header of file BAR90299.DAT would look like this:

90, 299, 2 , 60 , 61

Here the 90 stands for the year, the 299 is the Julian date, the 2 is the station number, the 60 is the channel number for pressure mean, and the 61 is the channel number for pressure standard deviation. These last three items are supplied by the AIR-ID.CFG file, which is described in section 5.1.

Subsequent data lines might look like this:

00:00:00	2255	993.69	.1008853
00:05:00	2257	993.68	.1004578
00:10:00	2255	993.67	.1011615

The first column is the start time of the sample period. The second column is the number of pressure readings AIR-DB.EXE received during the sample period. Because the sample period here is 5 minutes, one would expect to have 3000 readings. The reader will note that somewhat fewer readings were received. This is normal and due to the fact that hand shaking between the computer and the barometer slows the data-transfer process slightly.

The third column in the above example is the mean pressure in millibars. The last column is the standard deviation of pressure.



## 6.0 HANDLAP Software Description

The HANDLAP program was written for laptop computers that use MS-DOS. The function of HANDLAP is to retrieve meteorological data from a HANDAR 540 Data-Capture Platform (DCP). It relies on the HANDAR smart dump option.<sup>(6-1)</sup> It may be run in either the automatic, interactive, or menu mode. Prior to running the program, the serial ports of both the DCP and computer should be connected using the special HANDAR cable.

### 6.1 Software Initialization

When HANDLAP is first run, it reads a file called HANDCOM.CFG. The initial parameters to be used for its operation may be found in this file. A sample of this file is presented in Figure 6-1.

The values for most of these entries may be altered and saved by using the main menu, which is shown in Figure 6-2. The DCP will always default to 300 baud unless the baud rate has been changed during an earlier session and the computer has been left connected to the DCP.

The time periods on lines 5, 6, 7, and 8 refer to the period of time over which data will be requested of the DCP by HANDLAP. If the program is started in the automatic mode, as described in section 2.1, the total time from these four lines will be used in conjunction with the current real time to calculate a start time and date for the data request. The end time for the data report will always be the current time when the automatic mode is used.

Line	Configuration data	Explanation
1.	COM1	Serial Port
2.	300	Baud Rate
3.	,E,7,1,CS0,DS0,CD0	Communication Parameters
4.	600	time out (seconds)
5.	15	Data period in minutes
6.	0	" " " hours
7.	0	" " " days
8.	0	" " " years
9.	0	Hours offset from local time
10.	R	Two character identifier for data file

Figure 6-1. Sample HANDCOM.CFG file.

The two-character identifier shown on line 10 of Figure 6-1 is used when data-logging file names are generated by the program. They may be changed by editing this HANDCOM.CFG with a text editor.

## **6.2 Running the Program.**

HANDLAP may be invoked in several different ways, depending upon what the user wants to do.

### **6.2.1 Method 1: Automatic Mode**

From the DOS prompt, type HANDLAP <Enter> or HANDLAP \* <Enter>.

When the program is started in this way, it expects that the computer has already been connected to the 540 DCP. HANDLAP will request that the DCP deliver meteorological data from the time period specified in the HANDCOM.CFG configuration file. When the last datum has been received, the HANDLAP program will terminate. If the program's timer runs out before all of the data are retrieved from the DCP, the program will end at that time.

If the program commands listed in section 3.0 are used before the program terminates, an automatic mode session may be converted to either a menu mode or interactive mode session.

### **6.2.2 Method 2: Interactive Mode**

From the DOS prompt, type HANDLAP B <Enter>.

The program will start in the interactive mode but will do nothing else until told to do so. The program timer does not function when this mode has been invoked. Any command in the *540A Operating & Service Manual*<sup>(6-1)</sup> may be issued to the 540A DCP in this mode. In addition, the program commands listed in Chapter 3 may be used as well.

### **6.2.3 Method 3: Menu Mode**

From the DOS prompt, type HANDLAP A <Enter>.

The program will start up in the menu mode. This allows the user to change the configuration table for the program or to select a polling period different from



that in the configuration table. The program timer does not function in this mode. Samples of the main and auxiliary menus are presented in Figures 6-2 and 6-3.

A menu item may be selected by pressing the up or down arrow key until the item is highlighted. In addition, it may usually be selected by typing the first letter of its name. Once selected, the item may be changed from the keyboard. (Y)es or (N)o items may be toggled to yes with the <Y> key. Changes to items like BAUD rate and PARITY must be typed. The program will accept a change to a menu selection only by the pressing of the <Enter> key.

026 11:00:04	
Smart Dump Program for Handar 540	
Communication Port	: 1
Baud rate	: 300
Parity - E, O, N	: E
Word length, 7 or 8	: 7
Stop bits, 1 or 2	: 1
Time-out (minutes)	: 800
Minutes of report	: 15
Hours of report	: 0
Days of report	: 0
Years offset	: 0
GMT offset (hours)	: 0
Auxiliary menu	: N
File Save	: N
End MENU mode	: N
Quit program	: N

Figure 6-2: Example of HANDLAP main menu.

026 11:02:15	
Auxiliary data retrieval menu	
Date start	: 026
Start time	: 10:46:00
End date	: 026
Time, end	: 11:01:00
Poll data	: N
Quit menu	: N

Figure 6-3. Example of HANDLAP auxiliary menu.

### 6.2.4 Changing the Data-Logging Disk Drive

From the DOS prompt, type `HANDLAP x D <Enter>`, where `x` is one of the above invocation arguments (either `*`, `A` or `B`) and `D` is the desired logging disk drive.

The program will start up in the mode specified and log all data to the alternate disk drive. This option is available in `HANDLAP` version 2.4 or higher.

### 6.3 Interactive Mode Commands

The following commands may be used when `HANDLAP` is not in the menu mode.

KEY STROKE	ACTION
<F1>	Causes the menu mode to be selected.
<F2>	Will allow a new program to be loaded into the 540. The DCP must be in the program mode. See Appendix A.
<F3>	Will allow the program on the 540 to be saved on the computer. The DCP must be in the program mode. See Appendix A.
B	Puts the program in the interactive mode. This terminates the program timer, and interactive communications between the keyboard and serial port are possible. A smart modem may be dialed directly from the program in this mode.
E	Causes an automatic smart dump to be disabled. The program timer will continue to run unless the B mode, above, was used previously. Use this mode to give other commands to the 540.
/	Causes a smart dump to be requested from the 540 DCP.
<Ctrl><C>	Causes the program to terminate. <Ctrl><Break> may be used if a dial-up modem is not in use.

### 6.4 Data Files

Two kinds of data files are generated from each smart dump. The name of the first type always starts with the Julian date on which it was created. All data collected on the same day will be put in the same file regardless of how many times

this program is run. An example of this kind of file would be 293\_R90.PRN, where 293 is the Julian date, and 90 is the year.

The general format would be DDD\_RYY.PRN.

The second type of data file contains the latest scan from the 540 DCP. It will always be located in the \RAWDAT directory and will be named TEMP1.DAT. On a system with a hard disk it will be called:

C:\RAWDAT\TEMP1.DAT

## 6.5 HANDAR 540A Configuration

The following is the code listing for the HANDAR 540a configured for radon-data aquisition.

```

P   ID                      00000001 *****
P   STATION TIME            13:53:02  *
P   YEAR (XX)                90      * RADON 540 listing *
P   DCP JULIAN DATE          278      * 10-05-90 *
P   GMT TIME NOT IMPLEMENTED *
P   DIFT TIME NOT IMPLEMENTED YET *****
P   TIMED REPORT TYPE        00
P   SEC REPORT TYPE          00
P   COMMUNICATION TYPE       00
P   MAX MESSAGE LENGTH       512
P   TEL #:AREA CODE          0-000
P   TEL #:LOCAL              000-0000
P   DIAL OUT FORMAT          00
P   DIAL IN FORMAT           00
P   PROG TIME (1=Y,0=N)      00
P   1ST DIAL TIME            00:00:00
P   DIAL INTERVAL            00:00:00
P   TEL EMG XMIT 1=ON        00
P   AUTO DUMP? 1=Y 0=N       00
P   1ST LOG TIME             00:00:00
P   LOG INTERVAL            00:00:00
P   DRIVE MODE               00
P   LOG MODE                 00
P   VOICE OUTPUT MODE        00
P   TOUCH TONE PASSWD        0
P   CHANNEL NO.              01
P01 SENSOR TYPE              10
P01 SENSOR NAME TAG          10
P01 CARD SLOT #              01
P01 SENSOR INPUT ADRS        1
P01 SENSOR PWR ADRS          9

```

P01	SENSOR PWR ADV	00:00:02
P01	*FULL SCALE	5.000
P01	ZERO SCALE	0.000
P01	MEAS INTERVAL	00:05:00
P01	START OF MEAS	13:50:00
P01	LEVEL 1 MEAS TYPE	002
P01	LEVEL 1 SAMP INTVL	00:00:01
P01	LVL1 DATA SET SIZE	00300
P01	LEVEL 2 MEAS TYPE	001
P01	XMIT 2 OR 3 BYTES?	03
P01	HIGH LIMIT	NO LIMIT
P01	LOW LIMIT	NO LIMIT
P01	HIGH DIFF LIMIT	NO LIMIT
P01	LOW DIFF LIMIT	NO LIMIT
P	CHANNEL NO.	02
P02	SENSOR TYPE	10
P02	SENSOR NAME TAG	10
P02	CARD SLOT #	01
P02	SENSOR INPUT ADRS	4
P02	SENSOR PWR ADRS	8
P02	SENSOR PWR ADV	00:00:02
P02	*FULL SCALE	5.000
P02	ZERO SCALE	0.000
P02	MEAS INTERVAL	00:05:00
P02	START OF MEAS	13:50:00
P02	LEVEL 1 MEAS TYPE	002
P02	LEVEL 1 SAMP INTVL	00:00:01
P02	LVL1 DATA SET SIZE	00300
P02	LEVEL 2 MEAS TYPE	001
P02	XMIT 2 OR 3 BYTES?	03
P02	HIGH LIMIT	NO LIMIT
P02	LOW LIMIT	NO LIMIT
P02	HIGH DIFF LIMIT	NO LIMIT
P02	LOW DIFF LIMIT	NO LIMIT
P	CHANNEL NO.	05
P05	SENSOR TYPE	10
P05	SENSOR NAME TAG	10
P05	CARD SLOT #	01
P05	SENSOR INPUT ADRS	8
P05	SENSOR PWR ADRS	8
P05	SENSOR PWR ADV	00:00:02
P05	*FULL SCALE	5.000
P05	ZERO SCALE	0.000
P05	MEAS INTERVAL	00:05:00
P05	START OF MEAS	13:50:00
P05	LEVEL 1 MEAS TYPE	002
P05	LEVEL 1 SAMP INTVL	00:00:03
P05	LVL1 DATA SET SIZE	00100
P05	LEVEL 2 MEAS TYPE	001
P05	XMIT 2 OR 3 BYTES?	03
P05	HIGH LIMIT	NO LIMIT
P05	LOW LIMIT	NO LIMIT
P05	HIGH DIFF LIMIT	NO LIMIT
P05	LOW DIFF LIMIT	NO LIMIT

P	CHANNEL NO.	06
P06	SENSOR TYPE	10
P06	SENSOR NAME TAG	10
P06	CARD SLOT #	01
P06	SENSOR INPUT ADRS	9
P06	SENSOR PWR ADRS	8
P06	SENSOR PWR ADV	00:00:02
P06	*FULL SCALE	5.000
P06	ZERO SCALE	0.000
P06	MEAS INTERVAL	00:05:00
P06	START OF MEAS	13:50:00
P06	LEVEL 1 MEAS TYPE	002
P06	LEVEL 1 SAMP INTVL	00:00:03
P06	LVL1 DATA SET SIZE	00100
P06	LEVEL 2 MEAS TYPE	001
P06	XMIT 2 OR 3 BYTES?	03
P06	HIGH LIMIT	NO LIMIT
P06	LOW LIMIT	NO LIMIT
P06	HIGH DIFF LIMIT	NO LIMIT
P06	LOW DIFF LIMIT	NO LIMIT
P	CHANNEL NO.	10
P10	SENSOR TYPE	10
P10	SENSOR NAME TAG	10
P10	CARD SLOT #	01
P10	SENSOR INPUT ADRS	F
P10	SENSOR PWR ADRS	B
P10	SENSOR PWR ADV	00:00:02
P10	*FULL SCALE	5.000
P10	ZERO SCALE	0.000
P10	MEAS INTERVAL	00:05:00
P10	START OF MEAS	13:50:00
P10	LEVEL 1 MEAS TYPE	002
P10	LEVEL 1 SAMP INTVL	00:00:03
P10	LVL1 DATA SET SIZE	00100
P10	LEVEL 2 MEAS TYPE	001
P10	XMIT 2 OR 3 BYTES?	03
P10	HIGH LIMIT	NO LIMIT
P10	LOW LIMIT	NO LIMIT
P10	HIGH DIFF LIMIT	NO LIMIT
P10	LOW DIFF LIMIT	NO LIMIT
P	CHANNEL NO.	11
P11	SENSOR TYPE	10
P11	SENSOR NAME TAG	10
P11	CARD SLOT #	02
P11	SENSOR INPUT ADRS	1
P11	SENSOR PWR ADRS	9
P11	SENSOR PWR ADV	00:00:02
P11	*FULL SCALE	5.000
P11	ZERO SCALE	0.000
P11	MEAS INTERVAL	00:05:00
P11	START OF MEAS	13:50:00
P11	LEVEL 1 MEAS TYPE	002
P11	LEVEL 1 SAMP INTVL	00:00:03
P11	LVL1 DATA SET SIZE	00100

P11	LEVEL 2 MEAS TYPE	001
P11	XMIT 2 OR 3 BYTES?	03
P11	HIGH LIMIT	NO LIMIT
P11	LOW LIMIT	NO LIMIT
P11	HIGH DIFF LIMIT	NO LIMIT
P11	LOW DIFF LIMIT	NO LIMIT
P	CHANNEL NO.	12
P12	SENSOR TYPE	10
P12	SENSOR NAME TAG	10
P12	CARD SLOT #	02
P12	SENSOR INPUT ADRS	4
P12	SENSOR PWR ADRS	8
P12	SENSOR PWR ADV	00:00:02
P12	*FULL SCALE	5.000
P12	ZERO SCALE	0.000
P12	MEAS INTERVAL	00:05:00
P12	START OF MEAS	13:50:00
P12	LEVEL 1 MEAS TYPE	003
P12	LEVEL 1 SAMP INTVL	00:00:01
P12	LVL1 DATA SET SIZE	00300
P12	LEVEL 2 MEAS TYPE	001
P12	XMIT 2 OR 3 BYTES?	03
P12	HIGH LIMIT	NO LIMIT
P12	LOW LIMIT	NO LIMIT
P12	HIGH DIFF LIMIT	NO LIMIT
P12	LOW DIFF LIMIT	NO LIMIT
P	CHANNEL NO.	13
P13	SENSOR TYPE	10
P13	SENSOR NAME TAG	10
P13	CARD SLOT #	02
P13	SENSOR INPUT ADRS	5
P13	SENSOR PWR ADRS	8
P13	SENSOR PWR ADV	00:00:02
P13	*FULL SCALE	5.000
P13	ZERO SCALE	0.000
P13	MEAS INTERVAL	00:05:00
P13	START OF MEAS	13:50:00
P13	LEVEL 1 MEAS TYPE	003
P13	LEVEL 1 SAMP INTVL	00:00:01
P13	LVL1 DATA SET SIZE	00300
P13	LEVEL 2 MEAS TYPE	001
P13	XMIT 2 OR 3 BYTES?	03
P13	HIGH LIMIT	NO LIMIT
P13	LOW LIMIT	NO LIMIT
P13	HIGH DIFF LIMIT	NO LIMIT
P13	LOW DIFF LIMIT	NO LIMIT
P	CHANNEL NO.	14
P14	SENSOR TYPE	10
P14	SENSOR NAME TAG	10
P14	CARD SLOT #	02
P14	SENSOR INPUT ADRS	6
P14	SENSOR PWR ADRS	8
P14	SENSOR PWR ADV	00:00:02
P14	*FULL SCALE	5.000

P14	ZERO SCALE	0.000
P14	MEAS INTERVAL	00:05:00
P14	START OF MEAS	13:50:00
P14	LEVEL 1 MEAS TYPE	003
P14	LEVEL 1 SAMP INTVL	00:00:01
P14	LVL1 DATA SET SIZE	00300
P14	LEVEL 2 MEAS TYPE	001
P14	XMIT 2 OR 3 BYTES?	03
P14	HIGH LIMIT	NO LIMIT
P14	LOW LIMIT	NO LIMIT
P14	HIGH DIFF LIMIT	NO LIMIT
P14	LOW DIFF LIMIT	NO LIMIT
P	CHANNEL NO.	15
P15	SENSOR TYPE	10
P15	SENSOR NAME TAG	10
P15	CARD SLOT #	02
P15	SENSOR INPUT ADRS	8
P15	SENSOR PWR ADRS	8
P15	SENSOR PWR ADV	00:00:02
P15	*FULL SCALE	5.000
P15	ZERO SCALE	0.000
P15	MEAS INTERVAL	00:05:00
P15	START OF MEAS	13:50:00
P15	LEVEL 1 MEAS TYPE	002
P15	LEVEL 1 SAMP INTVL	00:00:01
P15	LVL1 DATA SET SIZE	00300
P15	LEVEL 2 MEAS TYPE	001
P15	XMIT 2 OR 3 BYTES?	03
P15	HIGH LIMIT	NO LIMIT
P15	LOW LIMIT	NO LIMIT
P15	HIGH DIFF LIMIT	NO LIMIT
P15	LOW DIFF LIMIT	NO LIMIT
P	CHANNEL NO.	16
P16	SENSOR TYPE	10
P16	SENSOR NAME TAG	10
P16	CARD SLOT #	02
P16	SENSOR INPUT ADRS	9
P16	SENSOR PWR ADRS	8
P16	SENSOR PWR ADV	00:00:02
P16	*FULL SCALE	5.000
P16	ZERO SCALE	0.000
P16	MEAS INTERVAL	00:15:00
P16	START OF MEAS	13:45:00
P16	LEVEL 1 MEAS TYPE	002
P16	LEVEL 1 SAMP INTVL	00:00:20
P16	LVL1 DATA SET SIZE	00045
P16	LEVEL 2 MEAS TYPE	001
P16	XMIT 2 OR 3 BYTES?	03
P16	HIGH LIMIT	NO LIMIT
P16	LOW LIMIT	NO LIMIT
P16	HIGH DIFF LIMIT	NO LIMIT
P16	LOW DIFF LIMIT	NO LIMIT
P	CHANNEL NO.	20
P20	SENSOR TYPE	10

P20	SENSOR NAME TAG	10
P20	CARD SLOT #	02
P20	SENSOR INPUT ADRS	F
P20	SENSOR PWR ADRS	B
P20	SENSOR PWR ADV	00:00:02
P20	*FULL SCALE	5.000
P20	ZERO SCALE	0.000
P20	MEAS INTERVAL	00:15:00
P20	START OF MEAS	13:45:00
P20	LEVEL 1 MEAS TYPE	002
P20	LEVEL 1 SAMP INTVL	00:00:20
P20	LVL1 DATA SET SIZE	00045
P20	LEVEL 2 MEAS TYPE	001
P20	XMIT 2 OR 3 BYTES?	03
P20	HIGH LIMIT	NO LIMIT
P20	LOW LIMIT	NO LIMIT
P20	HIGH DIFF LIMIT	NO LIMIT
P20	LOW DIFF LIMIT	NO LIMIT
P	CHANNEL NO.	21
P21	SENSOR TYPE	10
P21	SENSOR NAME TAG	10
P21	CARD SLOT #	03
P21	SENSOR INPUT ADRS	1
P21	SENSOR PWR ADRS	9
P21	SENSOR PWR ADV	00:00:02
P21	*FULL SCALE	5.000
P21	ZERO SCALE	0.000
P21	MEAS INTERVAL	00:15:00
P21	START OF MEAS	13:45:00
P21	LEVEL 1 MEAS TYPE	002
P21	LEVEL 1 SAMP INTVL	00:00:20
P21	LVL1 DATA SET SIZE	00045
P21	LEVEL 2 MEAS TYPE	001
P21	XMIT 2 OR 3 BYTES?	03
P21	HIGH LIMIT	NO LIMIT
P21	LOW LIMIT	NO LIMIT
P21	HIGH DIFF LIMIT	NO LIMIT
P21	LOW DIFF LIMIT	NO LIMIT
P	CHANNEL NO.	22
P22	SENSOR TYPE	10
P22	SENSOR NAME TAG	10
P22	CARD SLOT #	03
P22	SENSOR INPUT ADRS	4
P22	SENSOR PWR ADRS	8
P22	SENSOR PWR ADV	00:00:02
P22	*FULL SCALE	5.000
P22	ZERO SCALE	0.000
P22	MEAS INTERVAL	00:15:00
P22	START OF MEAS	13:45:00
P22	LEVEL 1 MEAS TYPE	002
P22	LEVEL 1 SAMP INTVL	00:00:20
P22	LVL1 DATA SET SIZE	00045
P22	LEVEL 2 MEAS TYPE	001
P22	XMIT 2 OR 3 BYTES?	03



P22	HIGH LIMIT	NO LIMIT
P22	LOW LIMIT	NO LIMIT
P22	HIGH DIFF LIMIT	NO LIMIT
P22	LOW DIFF LIMIT	NO LIMIT
P	CHANNEL NO.	25
P25	SENSOR TYPE	10
P25	SENSOR NAME TAG	10
P25	CARD SLOT #	03
P25	SENSOR INPUT ADRS	F
P25	SENSOR PWR ADRS	B
P25	SENSOR PWR ADV	00:00:02
P25	*FULL SCALE	5.000
P25	ZERO SCALE	0.000
P25	MEAS INTERVAL	00:05:00
P25	START OF MEAS	13:50:00
P25	LEVEL 1 MEAS TYPE	002
P25	LEVEL 1 SAMP INTVL	00:00:01
P25	LVL1 DATA SET SIZE	00300
P25	LEVEL 2 MEAS TYPE	001
P25	XMIT 2 OR 3 BYTES?	03
P25	HIGH LIMIT	NO LIMIT
P25	LOW LIMIT	NO LIMIT
P25	HIGH DIFF LIMIT	NO LIMIT
P25	LOW DIFF LIMIT	NO LIMIT
P	CHANNEL NO.	26
P26	SENSOR TYPE	10
P26	SENSOR NAME TAG	10
P26	CARD SLOT #	03
P26	SENSOR INPUT ADRS	F
P26	SENSOR PWR ADRS	B
P26	SENSOR PWR ADV	00:00:02
P26	*FULL SCALE	5.000
P26	ZERO SCALE	0.000
P26	MEAS INTERVAL	00:05:00
P26	START OF MEAS	13:50:00
P26	LEVEL 1 MEAS TYPE	003
P26	LEVEL 1 SAMP INTVL	00:00:01
P26	LVL1 DATA SET SIZE	00300
P26	LEVEL 2 MEAS TYPE	001
P26	XMIT 2 OR 3 BYTES?	03
P26	HIGH LIMIT	NO LIMIT
P26	LOW LIMIT	NO LIMIT
P26	HIGH DIFF LIMIT	NO LIMIT
P26	LOW DIFF LIMIT	NO LIMIT
P	CHANNEL NO.	30
P30	SENSOR TYPE	12
P30	SENSOR NAME TAG	12
P30	MEAS INTERVAL	00:15:00
P30	START OF MEAS	14:00:00
P30	LEVEL 1 MEAS TYPE	002
P30	LEVEL 1 SAMP INTVL	00:01:00
P30	LVL1 DATA SET SIZE	00006
P30	LEVEL 2 MEAS TYPE	001
P30	XMIT 2 OR 3 BYTES?	03

P30	HIGH LIMIT	NO LIMIT
P30	LOW LIMIT	NO LIMIT
P30	HIGH DIFF LIMIT	NO LIMIT
P30	LOW DIFF LIMIT	NO LIMIT
P	CHANNEL NO.	31
P31	SENSOR TYPE	08
P31	SENSOR NAME TAG	08
P31	CARD SLOT #	01
P31	SENSOR PWR ADV	00:00:02
P31	*FULL SCALE	05000
P31	ZERO SCALE	-5000
P31	MEAS INTERVAL	00:05:00
P31	START OF MEAS	13:50:00
P31	LEVEL 1 MEAS TYPE	002
P31	LEVEL 1 SAMP INTVL	00:00:01
P31	LVL1 DATA SET SIZE	00300
P31	LEVEL 2 MEAS TYPE	001
P31	XMIT 2 OR 3 BYTES?	03
P31	HIGH LIMIT	NO LIMIT
P31	LOW LIMIT	NO LIMIT
P31	HIGH DIFF LIMIT	NO LIMIT
P31	LOW DIFF LIMIT	NO LIMIT
P	CHANNEL NO.	32
P32	SENSOR TYPE	08
P32	SENSOR NAME TAG	08
P32	CARD SLOT #	02
P32	SENSOR PWR ADV	00:00:02
P32	*FULL SCALE	05000
P32	ZERO SCALE	-5000
P32	MEAS INTERVAL	00:05:00
P32	START OF MEAS	13:50:00
P32	LEVEL 1 MEAS TYPE	002
P32	LEVEL 1 SAMP INTVL	00:00:01
P32	LVL1 DATA SET SIZE	00300
P32	LEVEL 2 MEAS TYPE	001
P32	XMIT 2 OR 3 BYTES?	03
P32	HIGH LIMIT	NO LIMIT
P32	LOW LIMIT	NO LIMIT
P32	HIGH DIFF LIMIT	NO LIMIT
P32	LOW DIFF LIMIT	NO LIMIT
P	CHANNEL NO.	33
P33	SENSOR TYPE	08
P33	SENSOR NAME TAG	08
P33	CARD SLOT #	03
P33	SENSOR PWR ADV	00:00:02
P33	*FULL SCALE	05000
P33	ZERO SCALE	-5000
P33	MEAS INTERVAL	00:05:00
P33	START OF MEAS	13:50:00
P33	LEVEL 1 MEAS TYPE	002
P33	LEVEL 1 SAMP INTVL	00:00:01
P33	LVL1 DATA SET SIZE	00300
P33	LEVEL 2 MEAS TYPE	001
P33	XMIT 2 OR 3 BYTES?	03

P33	HIGH LIMIT	NO LIMIT
P33	LOW LIMIT	NO LIMIT
P33	HIGH DIFF LIMIT	NO LIMIT
P33	LOW DIFF LIMIT	NO LIMIT
P	CHANNEL NO.	51
P51	SENSOR TYPE	10
P51	SENSOR NAME TAG	10
P51	CARD SLOT #	01
P51	SENSOR INPUT ADRS	1
P51	SENSOR PWR ADRS	9
P51	SENSOR PWR ADV	00:00:02
P51	*FULL SCALE	5.000
P51	ZERO SCALE	0.000
P51	MEAS INTERVAL	00:05:00
P51	START OF MEAS	13:50:00
P51	LEVEL 1 MEAS TYPE	003
P51	LEVEL 1 SAMP INTVL	00:00:01
P51	LVL1 DATA SET SIZE	00300
P51	LEVEL 2 MEAS TYPE	001
P51	XMIT 2 OR 3 BYTES?	03
P51	HIGH LIMIT	NO LIMIT
P51	LOW LIMIT	NO LIMIT
P51	HIGH DIFF LIMIT	NO LIMIT
P51	LOW DIFF LIMIT	NO LIMIT
P	CHANNEL NO.	52
P52	SENSOR TYPE	10
P52	SENSOR NAME TAG	10
P52	CARD SLOT #	01
P52	SENSOR INPUT ADRS	4
P52	SENSOR PWR ADRS	8
P52	SENSOR PWR ADV	00:00:02
P52	*FULL SCALE	5.000
P52	ZERO SCALE	0.000
P52	MEAS INTERVAL	00:05:00
P52	START OF MEAS	13:50:00
P52	LEVEL 1 MEAS TYPE	003
P52	LEVEL 1 SAMP INTVL	00:00:01
P52	LVL1 DATA SET SIZE	00300
P52	LEVEL 2 MEAS TYPE	001
P52	XMIT 2 OR 3 BYTES?	03
P52	HIGH LIMIT	NO LIMIT
P52	LOW LIMIT	NO LIMIT
P52	HIGH DIFF LIMIT	NO LIMIT
P52	LOW DIFF LIMIT	NO LIMIT

## 6.6 HANDAR Commands

The following commands may be required to start HANDAR data acquisition.

### 6.6.1 HANDAR Time

The HANDAR time must agree with the real time used in other parts of the system. To verify that the time is correct, run HANDLAP with the B option, and press J on the laptop computer's keyboard. The time will be displayed. Compare this to the current time. If a change is required, type in the new time and press <Enter>. Do not include the colons. Press v to view the year and v to view the Julian date. To change either of these parameters, simply type in the figure.

### 6.6.2 PROGRAM/RUN Mode

The 540A must be in the RUN mode to acquire data. When communicating with the HANDAR in the interactive mode, each line from the 504A will start with the letter R when it is in the RUN mode. If this letter is P, then the following procedures must be followed.

- Set the time as described in section 6.6.1.
- Type HNOV (do not use <Enter> here). The HANDAR should respond with

P01 START OF MEAS.

- Type in a time that is at least 2 minutes in the future, but do not use colons. After <Enter> is pressed, the 540A should respond with

P01 CHANGE ALL CHANS ? (1=Y, 2=N) .

If it does not, try typing HNOV again. When the above response is received from the 540A, press 1 for yes.

- Now type YSMVS. The 540A will respond with  
R RUN/MONITOR MODE  
R01 NEXT SCAN HH:MM:SS (where HH:MM:SS is a time)  
R CHANNEL NO. 01  
R CHANNEL NO. 02  
R02 NEXT SCAN HH:MM:SS (where HH:MM:SS is a time)

If either of the NEXT SCAN times is more that 30 minutes, terminate the RUN mode with a ?2 and start over with HNOV.

## References

- 6-1. HANDAR, Inc. (1983), *540A Multiple Access Data Acquisition System Operating and Service Manual*, HANDAR, Inc., Sunnyvale, CA.



## **7.0 Radon Data-Acquisition Procedures**

Chapters 1 through 6 of this document were provided as background for the operator of the Radon Data-Acquisition system. The reader should become familiar with those chapters before attempting to use this equipment.

The operator must perform many detailed functions at specific times during the course of an experiment. These functions may be broken down into four major operational phases. The first function is setup, where the equipment is checked out and prepared to run. The second phase is the actual start of the data-acquisition cycle, where the first radon samples are taken. The third phase takes place during the experiment. The goal of this phase is to assure that the equipment continues to work, the data buffers do not overflow, and the correct samples are taken in a timely manner. The last phase involves data transfer, equipment shut down, and data analysis.

To aid the user in following the procedures for each phase, a series of log sheets have been developed. They appear in Appendix 7-A.

### **7.1 Setting Up the Experiment**

When the experiment is first started, the operator must check the connections between all components, apply power to all equipment, check the functionality of each piece of equipment, synchronize the real-time clocks of each system, and start up all software programs required for system control and data acquisition.

#### **7.1.1 System Power**

Check the voltage on all external batteries. Because this system is designed for remote operations, a number of 12-volt batteries are used for power. They are charged either by large solar panels or by the intermittent use of battery chargers.

The voltage in these batteries will be about 13.7 volts when fully charged, and should not be allowed to fall below 12.1 volts. Should this happen, connect battery chargers on all of the low batteries. If solar panels are connected to these batteries, it may be necessary to disconnect them before charging. Check the manufacturer's instructions.

At sites where 120-volt AC power is available, the laptop computers, battery chargers, and the WLM-30 radon detector may be connected to 120-volt AC power.

Be sure that this supply is stable and reliable. In some sites, ground-fault interrupters are installed. These devices may become a problem during the rainy season if they are allowed to get wet.

At sites where 120-volt AC power is not available, all equipment must be operated by the batteries. Most of these batteries are rechargeable. During the charging cycle, water in the batteries' electrolyte may be lost, so fluids should be replaced as needed with distilled water.

When the WLM-30 is being run from an external 12-volt supply, it will not supply power to the RD-200 units. Under these circumstances, the RD-200s must be switched to internal power, which means that their alkaline batteries will need to be replaced from time to time.

### **7.1.2 Turn the System On**

Turn the following components of the system on:

- Toggle the WLM-30 to the ON position.
- Switch the RD-200 unit's power switch to external if the WLM-30 is using 120-volt AC power, or to internal if not. Press the sample button so that data will be acquired.
- Turn both laptop computers on and set the time on each one. For the Zenith computer, type `RTCLOCK mm/dd/yy hh:mm:ss <Enter>` `<Enter>`, where the arguments are month/day/year hour:minute:second. For the Tandy computer, press the `<Ctrl>`, `<Alt>`, `<Ins>`, and `<Shift>` keys simultaneously. Select `<F9>` if the time and date are to be changed. Move the cursor to the desired number with the `<Enter>` key, and type in the new number followed by `<Enter>`. Unchanged values must be accepted by pressing `<Enter>` until all time and date numbers have been accepted. Press `<Esc>` to leave the setup program.
- Check the switch settings on the Radon Monitor Controller (RMC). The RESET switch should be down, the RUN switch, and the CPU switch should be up. When the POWER switch is toggled up, the Scanivalves should move to the home position.



- Place both the POWER and PUMP switch on the TN-RG-20 radon detector in the up position. The internal pump should start to work.

### 7.1.3 Check System Interconnections

Figure 7-1 shows all system interconnections. Please verify that all components are connected to one another correctly.

- Computer 2 should be connected to the AIR-DB barometer by a special serial cable. This cable must be plugged in to the  $\pm 15$ -volt DC power supply or to the  $\pm 12$ -volt system of the RMC. Cables have been provided for this purpose.
- The RMC actuator unit must be connected to the RMC control unit by the power cable, the relay cable, the analog cable, and the digital cable. The two external batteries that provide the RMC with its  $\pm 12$ - and  $\pm 12$ -volt power supply must be connected to the actuator unit.
- Both RD-200 units must have their sample chambers in place. The sample of one of the RD-200s is connected to the RMC tower-air sample line through a 5-micron filter. The TN-RG-20 units sample line is connected to the exhaust port of the first RD-200. The other is connected to the RMC ground air sample line through a sub-micron filter.
- Connect the WLM-30's air-sample line to its dedicated sample port on the tower.
- Computer 1's serial port may be connected to either the A/B switch box or the RMC control unit.
- The A position of the A/B switch box is connected to the WLM-30 unit. The B position is connected to the HANDAR 540A.
- The Scanivalve sample lines on the RMC actuator unit must be connected to their respective sample points.



#### **7.1.4 Equipment Initialization — Cold Start**

The following procedures are required to start each experiment. Failure to follow them may jeopardize the experiment. It is recommended that the appropriate log sheets (Appendix 7-A) be used at this time.

**7.1.4.1 AIR-DB Barometer.** Be sure that power to the barometer is on. Verify the RS-232 connection between Computer 2 and the AIR-DB barometer.

**7.1.4.2 HANDAR 540A Interface.** Connect Computer 1 to the A/B switch box in the C position. Turn the selector to B and run `HANDLAP.EXE` with the B option (see section 6.2.2.). Verify that the HANDAR program is in the RUN mode and that the current HANDAR time agrees with the current time. This can be done by typing J. The HANDAR time will be displayed. If this is acceptable, and the first character on each line is R, then the HANDAR system is functioning properly.

**7.1.4.3 WLM-30 Interface.** Connect Computer 1 to the A/B switch box in the C position. Place the selector switch in the A position and run `RADCON`. Place the WLM-30 in the RUN position. Typing O <Enter> will display the current status of the WLM-30 and assure that communications have been achieved between the laptop and the WLM-30. Now type F <Enter> to transfer the current time and setup information to the WLM-30. The user can verify that the transfer took place by typing O <Enter>. The current time and date should agree with the time in the upper left hand corner of the the screen. Memory Erase should be displayed as Yes.

**7.1.4.4 RMC Setup and System Start-Up.** Connect Computer 1 to the RS-232 port of the RMC control unit. If `RADCON.EXE` is running, press <F2> to select the RMC otherwise, type

`RADCON 1 B 1 <Enter>` (where B is the data-logging drive).

Be sure that the RMC RUN switch is up, the CPU switch is up, and the POWER switch is up. Type V <Enter>, and set the end limit for Scanivalve position (e.g., 12, 4 <Enter>) and make any other configuration changes that are warranted. See section 2.5.1 for details on these options.

Radon data-acquisition experiments must start on the minute (i.e., 0 seconds) due to limitations of the WLM-30. With less than one minute before the start of the experiment, turn WLM-30 to the AUTO position. Toggle the RMC RUN switch to the

down position. At 20 seconds before the start of the experiment, type E <Enter>. The first ground-air sample should be drawn with the syringe and delivered to the detector by the time the WLM-30 starts.

**7.1.4.5 WLM-30 Check.** Sometimes the WLM-30 will not erase its memory at the start of an experiment. To be sure that enough free memory is available for the experiment, reconnect Computer 1's serial port to the A/B switch box and switch to A. If RADCON.EXE is running, select WLM30 by pressing <F1>. If not, run RADCON.EXE. Now type O <Enter> and verify that less than 2% of the memory is used. If there is insufficient memory, it may be necessary to restart the experiment.

## **7.2 Monitoring the Experiment**

Monitoring the progress of the experiment is desirable and often necessary. At the minimum, one should check to see that all components of the system are doing their jobs. This includes both software and hardware. In addition, options have been provided to allow near real-time acquisition from most of the sensors.

### **7.2.1 Software/Firmware Checks**

From time to time, check to see that AIR-DB.EXE is running and acquiring data from the digital barometer. The run state of the RMC and the WLM-30 should be checked with RADCON.EXE in the appropriate mode.

With Computer 1 connected to the RMC control unit, observe the data printed by the RMC to the computer. The count-up and count-down timers should be functioning, the Scanivalve position should be displayed, and the battery voltage and T&N counts should be printed every minute.

Run RADCON.EXE in the WLM30 mode on Computer 1. Connect its serial cable to the WLM-30. Type O <Enter>, and observe the current status (start time, stop time, and percent of memory free). If memory is getting close to being filled, it may be wise to restart the unit when the current cycle has finished.

### **7.2.2 Hardware Checks**

The WLM-30's RUN light and FILTER light should be on. Both RD-200 units' sample lights should be on. All wet-cell or gel-cell batteries should have a voltage of 12.1 or greater. If not, they should be recharged.

## **7.3 Near Real-Time Data Logging**

Data may be logged in near real time from the WLM-30, the RMC control unit, the HANDAR 540A, and the AIR-DB barometer. In the case of the AIR-DB barometer, this is required as part of the acquisition process. One of the laptop computers (Computer 2) is dedicated to this purpose. Under most circumstances, it is undesirable to leave a computer connected to the HANDAR 540A, because this will result in greater power consumption.

The HANDAR 540A, the RMC control unit, and the WLM-30 will store data internally for 23, 24, and 13 hours, respectively. This means that there is no absolute need to log data in near real time from these units. If redundancy or quality control of data is an issue, it may be desirable to log data as it is produced.

### **7.3.1 WLM-30 Near Real-Time Data Logging**

Connect the WLM-30 to Computer 1's serial port and run RADCON.EXE in the WLM30 mode. Type O <Enter> to get the WLM-30's status. Toggle data logging on with the <F4> key, and wait for the first new data line. If it does not appear within one minute, press <Enter>. The data will be logged each minute on the computer's current drive. It is useful to have this backup data in case it is lost from the WLM-30 before the data can be logged onto the computer at the end of the experiment.

### **7.3.2 RMC Near Real-Time Data Logging**

RADCON.EXE must be used in the RMC mode for near real-time data logging. Connect the RMC control units' RS-232 port to Computer 1 and press the <F4> key to toggle data logging on. Every minute, RADCON will store a line of data from the RMC control unit onto the current disk drive.

## **7.4 Mid-Experiment Data Logging**

If an experiment is to be run longer than the time limits specified in section 7.3, it will be necessary to log the data from each instrument to the computer during the course of the experiment. Be aware that data may be lost or delayed when these procedures are performed with the RMC or the WLM-30. No interruptions of data acquisition will result when data are logged from the HANDAR 540A.

### **7.4.1 HANDAR Data Logging**

Connect the RS-232 port of Computer 1 to the C position of the A/B box and switch to B. Run `HANDLAP.EXE` without argument. Twenty-four hours of data will be logged to the computer, and the program will stop. Be sure to switch the A/B box back to the A position when finished. This must be done to reduce the power consumption of the HANDAR unit.

### **7.4.2 AIR-DB Data Logging**

Normally nothing need be done with the AIR-DB system before the end of the experiment. The current day's data may be copied to a second disk by placing a formatted disk in an alternate drive on Computer 2 and typing the capital letter of that drive. If data files from other days are to be transferred, `AIR-DB.EXE` must be terminated by pressing `<Esc>`. The files may then be copied to the alternate drive with the DOS copy command. When finished, type `AIR-DB <Enter>`.

### **7.4.3 WLM-30 and RMC Data Logging**

Wait until the current ground-air data-acquisition cycle has ended. This will normally occur when the last purge step has finished and the ground-air Scanivalve moves to the next position.

**7.4.3.1 RMC Data Logging.** Connect the RS-232 port of Computer 1 to the RMC's RS-232 port. From the DOS prompt, type `MEX SET BAUD 4800 <Enter> T <Enter>`. Observe the run time display (which is discussed in section 2.5.2.1) and record the position of both Scanivalves (these are found in the third and fourth

fields) and the current elapse time (the first field). Now toggle the RMC's RUN switch to the up position. The RMC MAIN menu should now be displayed.

Press the <Fn> and <Home> keys at the same time and type TERMA FILE.NAM <Enter> T <Enter>, where FILE.NAM is the file name and extension under which the RMC data is to be stored. Now type R <Enter>. When the MAIN menu reappears, press the <Fn> and <Home> keys at the same time and then type DOS <Enter>. Remove the RS-232 line from the RMC unit.

**7.4.3.2 WLM-30 Data Logging.** Connect the RS-232 port of Computer 1 to the C position of the A/B box and select A. Turn the WLM-30's front panel switch from AUTO to ON. Run WLM30.EXE, select <F2> Data and press <F7> Store Daughters. Now type the file name to be used to store the data and press <Enter>. WLM30.EXE will overwrite any pre-existing file with the same name without checking for its presence. Therefore, be sure to use a unique name. Press <F10> to start the data transfer. When all of the data have been received, press <Enter>.

Exit from WLM30.EXE and run RADCON.EXE. Type O <Enter> to get the current status. Now type F <Enter> to transfer the current setup to the WLM-30.

**7.4.3.3 RMC Data Logging and Restart.** Connect the RS-232 port of Computer 1 to the RMC's RS-232 port. From the DOS prompt, type

RADCON 1 B 1 <Enter> (where B is the data logging drive).

Determine the the Scanivalve position by comparing the figures recorded in section 7.4.3.1 to the Scanivalve position table shown in Figure 2-15. If the tower-air Scanivalve did not advance before the RMC's RUN switch was placed in the MENU mode (up), add one step to the tower-air Scanivalve position. If this is greater than the last Scanivalve position, use a position of 1.

Now type C <Enter> and enter the Scanivalve positions recorded in sections 7.4.3.1 and 7.4.3.3 (e.g., 11, 3). Now press <Enter>. When there are less than 60 seconds before the time when the experiment is to be restarted, turn the WLM-30 to the AUTO position. It is necessary to pause briefly at the OFF position. Turn the RMC's RUN switch to the down position. Twenty seconds before the experiment is to be restarted, type E <Enter> and verify that the first ground-air sample is taken.

The user may now follow any of the procedures in section 7.3 that are desired.

## **7.5 Terminating the Experiment**

Follow the data-logging procedures described in section 7.4. Consolidate all data files on a single disk for storage and data reduction. Check all battery-charging circuits to be sure that only the ones that can stay on permanently are left on. Turn off all equipment. Be sure to remove the AC adapters from the laptop computers.



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## Appendix 7-A

### Checklists and Log Sheets

**RADON Monitor & Control Checklist**  
**Cold-Start Procedures**

**Start-Up Procedures.**

date: \_\_\_\_\_

time: \_\_\_\_\_

**Check Battery Voltage**

1. RMC +12 (measured at the battery) : \_\_\_\_\_
2. RMC -12 (measured at the battery) : \_\_\_\_\_
3. WLM-30 and Computer 12-volt battery : \_\_\_\_\_
4. HANDAR external 12-volt battery : \_\_\_\_\_
5. Alkaline batteries (if used) : \_\_\_\_\_

**Turn Equipment On**

1. Turn T&N power and pump switches on : \_\_\_\_\_
2. Turn WLM-30 to the ON position : \_\_\_\_\_
3. Switch RD-200s to EXT if hard power, else to INT : \_\_\_\_\_
4. Press sample button on RD-200s : \_\_\_\_\_

**Use AIR-DB .EXE on Computer 2**

1. Use time of Computer 1 to set time #1's time : \_\_\_\_\_  
on Computer 2 #2's time : \_\_\_\_\_
2. Check available disk space, on Computer 2 : \_\_\_\_\_
3. Run AIR-DB .EXE : \_\_\_\_\_
4. Check for AIR-DB data acquisition : \_\_\_\_\_

**Use HANDLAP .EXE on Computer 1 (A/B box on B)**

1. Type HANDLAP B <Enter>. : \_\_\_\_\_
2. Check HANDAR program - number of lines : \_\_\_\_\_
3. Check HANDAR mode. (should = R) R/P : \_\_\_\_\_
4. Set HANDAR 540A time to Computer 1 — time : \_\_\_\_\_  
540A time : \_\_\_\_\_
5. Check 540 internal battery voltage : \_\_\_\_\_

**Set A/B box to A Position with Computer 1 on C. Run RADCON.**

1. Type O <Enter> to check status : \_\_\_\_\_
2. Type F <Enter> to set time, : \_\_\_\_\_  
memory erase, time, echo and start time

### Start Data Acquisition

1. Connect Computer 1 to the RMC : \_\_\_\_\_
2. Run RADCON . EXE in the Radon Con mode : \_\_\_\_\_
3. Place RUN switch in up position (Menu) : \_\_\_\_\_
4. Reset switch in the down position (normal) : \_\_\_\_\_
5. Turn CPU Power switch on : \_\_\_\_\_
6. Turn Main Power switch on : \_\_\_\_\_
7. Type V <Enter>. Set Scanivalve end positions (e.g., 12,4): \_\_\_\_\_
8. With less than 60 to start,  
Switch WLM-30 to AUTO : \_\_\_\_\_  
Set RMC RUN switch down : \_\_\_\_\_
9. Enter the desired start time of experiment : \_\_\_\_\_
10. At 20 seconds to start, type E <Enter>. time : \_\_\_\_\_  
Was ground-air sampled successfully? : \_\_\_\_\_

### When Run Has Started

1. Record Scanivalve AD counts for 1 and 2 : \_\_\_\_\_
2. Record RMC battery voltage : \_\_\_\_\_
3. Record RMC current time in seconds : \_\_\_\_\_
4. Check AUTO and FILTER lights on WLM-30 — on? : \_\_\_\_\_
5. Check air flowrate in l/min at tower for  
WLM-30 : \_\_\_\_\_  
RD-200/T&N : \_\_\_\_\_

NOTES: \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

**RADON Monitor & Control Checklist**  
**Data Logging and Re-Start**

Re-start or end run procedures

date: \_\_\_\_\_

time: \_\_\_\_\_

**Set A/B box to the B position with Computer 1 on C.**

1. Place data disk in desired disk drive : \_\_\_\_\_
2. Type HANDLAP \* B<Enter> where B is the desired data disk drive. Wait until data is logged : \_\_\_\_\_

**Use of AIR-DB.EXE on Computer 2.**

1. Press <Esc> to end the AIR-DB program : \_\_\_\_\_
2. Copy desired files to data disk. : \_\_\_\_\_  
Files are named as BARYyjjj.PRN where  
jjj is the Julian Date and yy is the year : \_\_\_\_\_
3. Type AIR-DB <Enter> to restart the program : \_\_\_\_\_

**Connect Computer 1 to RMC.**

1. Wait until the end of PURGE 2 : \_\_\_\_\_
2. With a DOS prompt, type MEX SET COM1 4800. : \_\_\_\_\_  
Type T <Enter>.
3. Record the actual time from Computer 1 : \_\_\_\_\_
4. Record RMC elapse time (field 1) : \_\_\_\_\_
5. Position of Scanivalve 1 and 2 (fields 3&4). : \_\_\_\_\_  
Convert from A/D units to steps.
6. Record battery voltage (field 5) : \_\_\_\_\_
7. Record T&N counts (field 6) : \_\_\_\_\_
8. Record battery voltage (field 5) : \_\_\_\_\_
9. Put RMC RUN switch in up position (Menu) : \_\_\_\_\_
10. Press <Fn><Home>
11. Type TERMA jjjTN.PRN <Enter> T <Enter> : \_\_\_\_\_  
where jjj is the Julian Date.
12. Press <Fn><Home> DOS <Enter> when finished : \_\_\_\_\_

Set A/B box to the A position with Computer 1 on C. Run WLM30.

1. Place WLM-30 switch in ON mode : \_\_\_\_\_
2. Select Read <F2>, Store Daughters <F7> : \_\_\_\_\_
3. Enter disk drive from <F2> (e.g., B:) : \_\_\_\_\_
4. Select file name, <F1> and enter name as : \_\_\_\_\_  
jjjSCX.PRN where jjj is the Julian date. CAUTION:  
If a file of the same name is already present, it will be over written.
5. After data has been retrieved, press <Enter>. : \_\_\_\_\_  
Press <F10><F10> and quit WLM30.
6. Run RADCON.EXE : \_\_\_\_\_
7. Press O <Enter> and read status : \_\_\_\_\_
8. Press F to transfer setup to WLM-30 : \_\_\_\_\_
9. Press O <Enter> and record times Current: \_\_\_\_\_  
Start: \_\_\_\_\_  
Stop: \_\_\_\_\_

**Connect Computer 1 to RMC.**

1. Run RADCON and Press <F2> to select RadCon : \_\_\_\_\_
- 2 Enter the desired start time here : \_\_\_\_\_
- 3 Press C. Enter Scanivalve start positions : \_\_\_\_\_
4. With less than 60 to start time, Switch WLM-30 to AUTO : \_\_\_\_\_  
Check RD-200s. Must be on : \_\_\_\_\_  
RD-200s must be counting : \_\_\_\_\_  
Set RMC RUN switch down (RUN position) : \_\_\_\_\_
5. At 20 seconds to start, type E <Enter> : \_\_\_\_\_  
Was ground-air sampled successfully? : \_\_\_\_\_

**When Equipment Has Re-Started**

1. Check AUTO and FILTER lights on WLM-30 — on? : \_\_\_\_\_
2. Check air flow rate in l/min at tower for:  
WLM-30 : \_\_\_\_\_  
RD-200/T&N : \_\_\_\_\_
3. Set up any near real time logging desired. : \_\_\_\_\_

NOTES: \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

